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PRACTICAL SMOKE PREVENTION.

BY

WILLIAM NICHOLSON.

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TO

SIR W. B. RICHMOND, R.A.,

PRESIDENT OF THE COAL SMOKE ABATEMENT SOCIETY,

AS A TOKEN OF

THE AUTHOR'S APPRECIATION OF HIS EFFORTS TO MINIMISE

THE SMOKE NUISANCE.

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PREFACE.

For a number of years prior to 1890 I have as an Engineer been interested in the great Smoke Question, and since the year named I have been Chief Smoke Inspector for the City of Sheffield. Having read a great deal that has been written on the subject, and having seen as far as possible every device that has been discovered, mechanical and otherwise, for the solution of the smoke problem, I have come to the conclusion that a hand-book dealing with Smoke Prevention from a practical standpoint was a desideratum. I have consequently attempted to write in such a way as to appeal to all classes of Boiler and Furnace Firemen, as well as to others who are indirectly and directly responsible for smoke-making.

(*a*) I have pointed out the common every-day and chief causes of preventable smoke in language that every fireman and furnaceman is conversant with.

(*b*) I have set forth in the simplest possible way the practical means and methods which, if carried out, will prove a certain cure for preventable smoke, without interfering with or obstructing trade in the slightest degree. In many instances the methods described have been carried out, and are being carried out to-day with the very best possible results.

(*c*) I have tried to show—and I trust successfully—that the fireman, if working under normal conditions, in spite of any machine he may have to assist him, has the cause and the cure of the smoke nuisance in his own hands; and he can, if he will, prevent at least 80 per cent. of the smoke which is now being belched into the atmosphere.

I have endeavoured to speak plainly on the practical aspect of the question, and I hope that my remarks will be sufficiently pointed to persuade both man and master to do their duty in dealing with this question, not only in order that they may benefit themselves, but that they may be enabled to confer an incalculable boon on the public health of the country.

WM. NICHOLSON.

SHEFFIELD.

PRACTICAL SMOKE PREVENTION.

CHAPTER I

COLOURS AND DENSITIES OF SMOKE.

Of all public and personal questions of to-day this should be the first, because it is a burning question in a twofold sense. Many have wished, and do wish to-day, that it was burnt out into nothingness, never to rise again; but of such a prospect at present there is little hope. During the present century, right away from its commencement, increasing in intensity as time rolled on, it has demanded recognition from the Press, the patentee, and the public. The Press has written much concerning it, and much praise is due to those who have sacrificed their time and talent and money in trying to solve this question. The ventilation of the subject has compelled men to think about it, and inspired them to determine, if possible, to discover some means by which to remedy the evil.

The patentee makes his advent on the scene of action, and says he will very soon put matters right. He, too, soon finds out that the task he has undertaken is an arduous one, and difficult withal. Many such, having started on the question fairly well off, have had to discontinue, poorer, but wiser men. Such persons are deserving of commendation in trying to do something for the public benefit, although at the same time trying to benefit themselves. The public has taken an interest in this question. Some have said there ought to be no smoke, and if they had their way all smoke would be suppressed. If such people had their way, not only would smoke be suppressed, but a large number of the population would not survive. On the other hand, the public in general have done much by agitation in bringing it nearer solution, and we would say to them, continue in the crusade until a satisfactory settlement is brought about.

(1) *Shades of Smoke.*—There are many shades or colours of smoke; some say seven, some more, and some only one, and that black. I remember hearing a witness before a certain tribunal state that there was only black smoke, no other kind or colour. He was a man past middle life, yet said "he had never seen any other kind of smoke than black, either in country or city." I need hardly remark that such evidence was not accepted by the Bench. He was either deliberately perjuring himself, or he had gone about life with his eyes shut. There are many shades and densities of smoke, which deserve our careful consideration, if we are to understand this question, and suggest anything practicable for its solution. The following are a few:—Black, dense black, thin black, brown, dense brown, dark brown, light brown, bluish cast, orange, or yellow, dense, and light. There are

many other shades and colours, too numerous to mention, each indicating a particular condition of working, which has to be considered in connection with the trade or process carried on. It would be the height of absurdity to generalise or summarise the whole, and say that every shade of smoke shall be stopped. It would simply mean the stoppage of commerce, and the ruin of the country. Our duty, then, is to examine the various shades, and, if possible, suggest practical means for their prevention.

(2) *Is Smoke a Nuisance?*—To this question we are compelled to answer in the affirmative; in spite of shades, colour, or density. Much of it is like very many other things which are acknowledged to be necessary evils. I do not contend for one moment that all smoke of whatever kind is necessary; but say, on the contrary, that much, if not most, of the smoke emitted is not necessary, and can be prevented.

(3) *Two Kinds of Smoke.*—For the sake of clearness, and the accomplishment of my purpose in these pages, I will assume that there are two classes or kinds of smoke:—(1) Preventable; and (2) Unpreventable. I mean by preventable, thick black smoke, or unburnt carbon emitted, which, by the application of a little common sense, could be consumed, and ought to be consumed, and which would be very profitable to the public and the manufacturer. Then there is the unpreventable smoke—the smoke which has lost its carbon constituents, which is thin when emitted from

the chimney, yet at the same time varying very much in colour. These gases must escape from the furnace and be discharged into the atmosphere, and there are no practicable means of preventing it, only by putting out the fires. There are some who consider themselves authorities on this question who say, "that this thin (light in many cases) unpreventable smoke ought to be taken into account," and say that if a chimney emits twenty minutes of this unpreventable smoke in one hour, this twenty should be divided by ten, which would make two minutes of black, preventable smoke, for which the sinner ought to be summoned. On the very face of it such an argument is untenable, for it is patent to every unbiassed mind that if you divide unpreventable smoke by ten times ten it will not make it preventable; yet there are those who advocate this system of smoke observation, and say that such a system is sensible. Such a system if enforced would inflict a gross injustice on the manufacturer by trying to compel him to do the impossible, and punishing him because he did not do it.

(4) *Public Health Act of* 1875.—Section 91 of this Act says:—"Any chimney (not being the chimney of a private dwelling-house) sending forth black smoke in such a quantity as to be a nuisance," shall be deemed a nuisance liable to be dealt with summarily in manner provided by this Act; and, further, that all furnaces and fireplaces must be constructed in such a manner as to consume, as far as practicable, the com-

bustibles used therein, having regard to the practice or process of manufacture.

There are three points in this section which control the legal machinery on this question:—(1) Practicability; (2) black smoke; and (3) the quantity to be a nuisance. Let us consider them for a moment in their order.

(1) *Practicability.*—Persons, trade, business, or process of manufacture must be considered first, that is if it is a legitimate one, and sanctioned by law, and the section does not enforce anything that is alien, or in the slightest degree calculated to hinder in any process or manufacture. It is necessary to be very clear on this point, for there are so many people who think the Local Authority has power under the Public Health Act to suppress smoke under any conditions, ignoring practicability altogether. If such a power was in the hands of Health Authorities it would be most arbitrary and disastrous to the commercial prosperity of the country. The section, then, is very simple, and means that if a manufacturer cannot practically prevent black smoke without interfering with his trade, then he can emit from his chimney dense volumes of smoke, and the Court has no jurisdiction in the matter. At first sight the section may seem strange and against the public health, but on careful examination one cannot but conclude that it is both just to the manufacturer and to the public.

(2) *Black Smoke.*—We must understand that the

Act does not deal with any other kind of smoke but black, no matter how dense or thick it may be emitted from the chimney. Black smoke is generally understood to be smoke through which you cannot see the light at the point of exit from the chimney, or smoke that is opaque, not transparent. All other sorts, colours, and densities of smoke are not under the Public Health Act considered a nuisance, therefore they are exempt from any restriction whatever.

It would be wise on the part of those who say hard things against the Local Authority for their inactivity and supineness in not suppressing smoke other than black, to remember that the Authority has no power to do it. If such facts were kept in mind we should have much less sentiment, and more common sense on the subject. I am not saying, nor do I wish to imply, that all Health Authorities have done everything they can on the subject; many have done next to nothing, while others are doing all they possibly can. What I do complain about is the wholesale charges for dereliction of supposed duties which they have neither moral nor legal right to discharge.

(3) *Such a Quantity as to be a Nuisance.*—Although Section 91 says black smoke is a nuisance, yet it must be emitted in a certain quantity in order to be a nuisance. In plain English, black smoke may be emitted in small quantities and not be considered a nuisance within the meaning of the Act.

The Act does not say what that quantity shall be, but leaves it for the Court to decide the matter on the evidence adduced. The Court can in this way, by the evidence, ascertain the conditions of working, the difficulties, and the possibilities of prevention of smoke, and by these means whether such a quantity has been sent forth as to constitute a nuisance. This question of quantity has been considered by the various administrative bodies, who, after a very careful consideration, have fixed various limits or standards by which to work. In fixing these limits the nature of the various trades in cities and towns have been considered, and the limit has been made low or high accordingly. The following is considered by many to be a reasonable allowance under all normal conditions:—One boiler, 2 min. in the hour; two boilers, 3 min.; three boilers, 4 min.; four boilers, 6 min.; and so on proportionately. If the smoke from a metallurgical furnace is discharged in the boiler chimney, then the lowest limit would be 6 min. in the hour, even if there was only one boiler. If there were more furnaces, then reasonable allowance would have to be made. The quantity of smoke from heating furnaces must be considered separately, as the conditions of working are so diverse and difficult. For one class of furnace 6 min. in the hour for one furnace would be reasonable; for another, 8 min.; and for another, 10 min. Where there are a large number of furnaces going into the same chimney, then the limit would have to be fixed accordingly. If the abovementioned limits are exceeded, then a nuisance exists, and proceedings follow for the abatement of the said nuisance.

My long experience at making smoke observations has forced me to come to the conclusion that there is a very great amount of dense, and practically preventable, smoke made which is not black, and therefore does not come within the smoke section of the Public Health Act of 1875. This kind of smoke is emitted in various shades, and is an intolerable nuisance, yet it escapes the law because of its colour, in spite of its density and its practical preventability.

I trust the reader will not think me presumptive in making one or two suggestions on this particular point for the amendment of Section 91, which I would suggest should read thus:—"A certain chimney, not being the chimney of a private dwelling-house, sending forth 'dense' smoke in such a quantity as to be a nuisance." The alteration is very slight, only substituting the word dense for black. However slight it may seem, and of little importance to the casual observer, yet such a small alteration would empower Local Authorities to proceed against makers of any kind of dense preventable smoke emitted in such a quantity as to be a nuisance, who at the present time cannot be proceeded against except it be black. This word black is one of the causes of the atmosphere of our large cities and towns being laden with unburnt carbon, because smoke-makers know full well that if they send out any other smoke but black there is no prospect of prosecution, and they very easily change it from black to some other colour. The suggested substitution of the word dense for black would in prosecutions prevent a lot of conflicting evidence as to colour in examination and cross-examination, and would also make it much easier to obtain convictions and penalties for unnecessary smoke. Looking at both sides of the question, we can safely say it would inflict no hardship or injustice on the manufacturer, but would only compel him to prevent the emission of unnecessary smoke, which would be to his advantage and to the advantage of the public health. I hope the day is not very far distant when our Legislature will see the advisability of making the suggested or similar amendments, which will embrace all preventable smoke in every-day working—it would prove very satisfactory.

CHAPTER II.

SMOKE FROM PRIVATE DWELLING-HOUSE CHIMNEYS.

THIS class of chimney is exempt from the smoke section of the Public Health Act. If we ventured to ask why, the answer would be, "Because they rarely or never emit black smoke." This is largely, if not wholly true, yet many chimneys turn out quantities of smoke which is beyond question a nuisance. The amount of smoke poured out from these chimneys in the aggregate is something enormous. If the reader desires proof, let him ascend some hill early on Sunday morning, and see to what extent the atmosphere is fouled when the populace are lighting the fires of dwelling-houses. I feel sure it will be a revelation, and will compel one to confess that all the smoke does not come from boilers and furnaces. Take a city like Sheffield, for instance, with its hundreds of thousands of fireplaces going daily, each emitting, say, only a thin brown smoke. What will the whole amount to? If it were possible to put closely together the particles of smoke emitted from the whole, say, in one day, we should be amazed at the amount of volume—sufficient, we should think, to put part of Sheffield in darkness; and this is taking place on the Sunday, when the boilers and furnaces have ceased from smoking, and the inspectors are at rest.

Looking fairly at the facts of this question, we must, to be honest, say that chimneys of dwelling-houses are partly responsible for the pollution of our atmosphere, and until we have a better system of heating our houses, and cooking our food, the nuisance will continue in a larger or lesser degree, unless we dispense with fires altogether.

Is there no practical means (under the present system of fireplaces) by which some of the smoke might be prevented? To such a question I say "Yes," but the amount is beyond our power to tabulate. This question of smoke and heat from dwelling-house fires has been for many years, and is now, agitating the minds of mechanics. The fires being of a slow combustible nature, send up the chimney unburnt gases which ought to be consumed, making heat to warm the house, and for other purposes. Great are the difficulties which confront would-be reformers in attempting a solution. Various methods of constructing the brick-work of the fireplace have been resorted to, viz., less area, sloping forward from the back, various classes of bricks set in different position to separate the particles, and at the same time igniting them by the heat retained in the said brick. Metal boxes have been placed in the chimney, and other contrivances, to catch the gases and combust them, regulating the required draught, so preventing some of the smoke which has been converted into heat, and used for the purposes desired. Very much has been attempted in this direction, but very little done toward a satisfactory solution. Until some practical, simple system, which can be universally adopted, of dealing with this class of fireplace is introduced, it is the duty of every householder to play his part in preventing as much smoke as possible, by putting on the fire smaller quantities of coal, which means more heat in the house, less coal consumed, and a little less smoke. This will mean a little more labour on the part of those attending to the fires; but the results will be most gratifying, when the individual littles are totalled in our large cities and towns.

CHAPTER III.

BLACK SMOKE FROM STEAM BOILERS.

It has become quite proverbial with men of a mechanical turn of mind, and many not mechanical (the latter the larger number), to say that all black smoke at all times can be prevented from steam boilers. To these we would say that such a statement is very much easier made than corroborated. I do not desire to deny that under ordinary conditions black smoke can be prevented, but there are at times extraordinary conditions which make prevention impossible (I shall deal with them later on), and these must not be ignored when considering (even with boilers) the practical solution. I have not the slightest desire in these columns to overstate or understate the truth; my object is to place before the reader the facts as I have found them, and not to be carried away by side issues into the sea of sentimentality.

Different Kinds of Steam Boilers.—It will be unnecessary to say much on the kind, class, size, shape, and structure of the very many boilers for generating steam in use at the present time. If I were to start on such a subject there would be sufficient matter on boilers alone to fill a large volume, but I would just say on behalf of 95 per cent. of the Sanitary Inspectors (who cannot be expected to possess mechanical knowledge, but who have in their duties to deal with this question), that when I speak of steam boilers I mean Lancashire boilers, which are the most popular, and are known as double-tubed boilers, horizontal. The Cornish boiler is similar to the Lancashire, with the exception of only having one tube, and not two. Then there is the cylinder and egg-ended boilers, which are a very old type, and are rapidly going out of use. There are also many kinds of vertical boilers. For instance, the marine class, which is becoming very popular owing to their occupying less space than Lancashire and similar boilers, while many claim also for them, with induced draught, greater evaporative power. Many other types of vertical boilers are used at temporary work because of their portability. There are also a large number of vertical boilers or coppers, as some call them, which are used chiefly in breweries for boiling the liquor. The construction is somewhat similar to other upright boilers, and the furnaces are practically worked like other boiler furnaces. I will assume that it is unnecessary to deal further in detail with boilers, as the reader will probably be in possession of all the working particulars connected therewith; but should he desire information regarding steam boilers, he may easily obtain it from books on the construction and working of boilers, as it would be a little outside the scope of the subject-matter of these articles to go further into the question.

Chief Causes of Black Smoke from Steam Boilers.—Having looked briefly at the different kinds of boilers, we are now called upon to ask why is black smoke made in these boilers? If there is disease, it is our duty, if we want to destroy that disease, to find out the cause. If that can be done, the cure will most surely follow. What are the causes, then, of black smoke? (1) Shortness of boiler power. To be under power means attempting to get out of the boiler more than is reasonable, and it is capable of doing, without detriment to it and damage to others. It is a most unfortunate position for any manufacturer to be in. It necessitates the undue forcing of the fires with damage to the boiler, the wasting of fuel, not having sufficient time for combustion, and the creation of a nuisance by the emission of black smoke. It may be said, why do manufacturers place themselves in such positions of helplessness? To such a question a lengthy answer is necessary, in order to consider all the relative facts. Let us look at a man so situated. He commences business, makes his calculations of the power required, also probable power; and buys the boiler, which he considers large enough for everything. As his business grows, machine after machine is added; each is worked to its utmost productive power, but the boiler gets no bigger, strange to say, though the load on it has increased considerably. The result is he finds himself short of boiler power. There is no room in many cases to put down another boiler, and if room were available, his business is of such a nature that to set down his works for a lengthened period would mean the losing of his trade entirely. A position like the one I have attempted to describe is not an isolated one, but is more general than many people imagine. This shortness of boiler room is one of the most prevalent causes of black smoke. Various methods may be tried in the way of apparatus, but it will invariably be found to aggravate rather than amend, unless the chief cause is removed.

(2) *Defective Draught.*—This is another cause of smoke, and one which has until recently not received that attention which its importance demands. There may be plenty of room in the boiler for generating steam, but that will be of very little use if the draught is insufficient, which means slow fires and imperfect combustion. In other words, defective draught is shortness of draught, and consequent failure to produce the necessary heat in the furnace to consume the coal placed in it, in the time necessary to prevent black smoke.

It is a very great mistake when building a chimney to erect a low one, thinking it will just serve for the purpose desired, when for a little extra cost a tall chimney, say 120ft. or more, might be put up, which would be found at some future time useful in serving other boilers or furnaces, which never entered the mind at the time of building. If the chimney creates too much draught it can easily be regulated by the damper, but if the draught is too little no damper will increase it. Artificial draught may be resorted to, but for uniformity of pull on the fires there is nothing to excel, or we might say equal, natural draught.

It is a big mistake to build little flues; they are soon made up, are difficult to clean, and are largely responsible for smoke. The cry is often heard from the engine tenter and firemen, "I have no flue room; I cannot keep up my steam." This is a complaint which is far more constant than it ought to be, for everything is to be gained by having big flues, better draught, more heat, less labour, and less expense in flue cleaning. Small chimneys and small flues are solely and wholly responsible for defective draught, and this is one cause of black smoke.

(3) *Common Coal.*—We are quite aware that the very best of coal, if not worked properly in the furnace, will, as the firemen say, "make a lot of smoke." This has been proved many times when using a coal full of gas, and when there has been negligence on the part of the man; but, on the other hand, the using of common coal, dirty, small, and almost gasless, means the making of smoke in trying to make steam. The cry is, "Look at what we have to burn." This cry is too frequent amongst firemen, and there are very just

grounds for their complaining when the quality of coal that they are expected to generate steam with is below par. If a fireman is compelled to use small and dirty coal, he is bound to emit a lot of black smoke in spite of every care in firing. His fires will become dirty, sluggish, almost dead; he will be compelled to use poker or rake, and the constant knocking about of the fires will inevitably create a nuisance. The extra labour for the firemen is excessive, and he invariably finds, in spite of all his attempts to keep up his steam, that it drops, with the result that the works have to stand until the steam is got up again. Many manufacturers have found out beyond the shadow of a doubt that cheap, or low-priced coal, at the pit mouth is not cheap in the end, but very costly; costly because of the enormous amount which has to be put through the boiler to obtain the results desired, costly by stoppages of the engine and machinery waiting for steam, and costly by creating a nuisance, owing to the consequences. Many means have been devised to burn common coal with satisfactory results, but they have in most cases failed, and many firms have gone back to their usual (bright nuts) class of coal, with the result that it has effected a saving of labour for the fireman, a saving in cost for the manufacturer, and last, but not least, the prevention of a black smoke nuisance. There is no doubt in the minds of men who are technically educated on the question that common or cheap coal is one of the causes of black smoke, and one that figures very largely in our great manufacturing centres even to-day.

(4) *Insufficient Information.*—Insufficient information on the part of the manufacturer and the fireman is almost incredible, when we come to consider what has been written, said, and done on this question; yet, if we face the facts, we are compelled to confess such is the case, and the absence of this knowledge of the scientific system of firing is one, if not the chief, cause of black smoke. When we speak of the scientific system of firing, we mean the very best rules and regulations for firing boilers or furnaces, which are so simple, that even the most obtuse of firemen may understand them and carry them out successfully. As to what they are, we shall explain them in detail later when dealing with the cures for black smoke.

The manufacturer may be excused for not understanding the practical working of furnaces; they have many other matters of business of greater importance, which absorbs all their time and attention, leaving this matter in the hands of their engineers, who in turn leave it to the firemen, who in many instances are not properly informed, hence black smoke. For the fireman there is no excuse for insufficient information on that which constitutes his daily duties. If he desires, he can secure it, with little effort and with little cost; but there seems on the part of many firemen a disinclination to obtain it. They no doubt think with Shakespeare that "where ignorance is bliss, 'tis a folly to be wise." We are not implying, for one moment, that all firemen lack this essential knowledge. If we did so it would be grossly unfair, because there are many who are well posted up in these particular points, and who take a delight in putting them into practice. To such we give that commendation which they deserve, but there is no disguising the fact that there are a large number who do discredit to themselves and to others, because of their lack of knowledge of their work.

Let us look for a moment at this class of man. He is put in charge, say, of three boilers. The foreman selects him for his strength and steadiness, and not because of any special knowledge he may possess about boiler working. He has knowledge of boilers, but very limited. He knows the water must be kept a certain height in the gauge glass; he must keep the steam up to, say, 50 lb., and to do this he must throw the coal on the fires. That is about the extent of the information some firemen possess in regard to boiler working. There is no one to instruct them; in fact, it is questionable whether many of them would receive instruction if such were offered. They have the opinion that they know sufficient, and no one can teach them more. Strength is very necessary for firing, but skill is more essential, and the class of man we have attempted to portray will either be compelled to inform himself on his work, or stand aside and make room for better informed men if insufficient information—one of the chief causes—is to be removed.

(5) *Inattention to Instructions.*—There is a class of man who is being constantly taught and told by the engineers and masters what he must do. He cannot plead ignorance; he can only plead inattention to given instruction. Such negligence is greatly culpable, and ought to be treated very severely. There is often a certain amount of excuse for a man who does what he ought not to do when in ignorance, though he might have procured the knowledge; but for the class of man in question, nothing will do him good but very drastic treatment. We do not desire for one moment to say he wilfully neglects to do his duty. It is an absent-mindedness or disinterestedness in his work, which, if not checked, becomes a habit with him, until one day he has his attention called to a nuisance he is creating, when he awakes out of his stupour or sleep, carries out these instructions he has so frequently received, and thus prevents any cause for complaint. Whilst it is necessary to know what is the cause of black smoke, such knowledge will be of no practical use unless applied in the desired direction. Occasional inattention (not general) will often get both master and man into disgrace.

(6) *Inactivity or Inertness.*—Of the three classes of men, we think the man who is inactive or inert is the most difficult to deal with. He knows what

ought to be done, he knows it is his duty to do it, but he will not do it unless he is constantly compelled. The lazy and slothful fireman will resort to all kinds of dodges and devices to escape a little labour. Self-ease and rest are his constant thoughts; he rests, and is tired, always tired, "born tired," and never would be rested even if he had nothing to do. This class is far more numerous than some would imagine, and very unfortunate are those who have such men in their employ. It is exceedingly hard for any master to be in the hands of such men, and liable for their neglect of duty, after having provided them with every modern appliance for the doing of their work efficiently. The reader may say the master has his remedy; he can discharge the men. Yes, that is true, but he is confronted with many difficulties. He may get men no better, slightly worse, or men unaccustomed to their particular class of work, or men who are unsteady, and who will work when they like. Being brought face to face with these things, and knowing the consequences to their business, it makes employers tolerate more from the lazy than they otherwise would. Being so situated, he chooses the lesser evil of the two, willingly paying the expenses attached to such sluggish stoking. There is one remedy I would suggest for inactive stoking, viz., strict supervision. If the men were constantly watched they would do their duty, and the cost of such supervision would be defrayed by the saving in many other ways, and another thing responsibility for much black smoke would be removed. The six causes briefly touched upon are mainly responsible for the dense volumes of smoke emitted into the atmosphere. There are, no doubt, many other little matters which need attending to in order to obtain complete combustion, but these need not be detailed here, as they are somewhat indirectly related to the causes named as being chiefly responsible for black smoke.

CHAPTER IV.

CERTAIN CURES.

THERE are as many remedies for the removal of the smoke nuisance as there are patent medicines to cure the disorders and diseases which human flesh is heir to. Many of them are almost as useful and valuable. The two available ways of dealing with the smoke question are: Practical smoke prevention and impractical smoke prevention. If we adopt the latter, the surest and safest cure is to let out all furnaces and fires; then very quickly there will be an end to the smoke problem. In so far as smoke is concerned, this method would be satisfactory, although hardly beneficial in any other way. Such action would mean ruin to commerce, comfort, and even life, and would be senseless in the extreme. Yet there are individuals who advocate such steps, simply because the smoke is a nuisance to them, and they will not personally suffer financially, being neither directly nor indirectly affected by trade. Again, there are others who have no practical knowledge of the question, who yet are constantly writing and saying what should be done, how it should be done, and why it should be done. Such persons have not the remotest idea of the great difficulties which have to be dealt with in the smoke question; if they had, we feel sure they would say less and think more.

However, we are not concerned in these pages with impracticable means. Our object is to treat of practical smoke prevention, and with reasonable ways and means which, whilst abating the smoke nuisance, will not unduly interfere with the individual or the community.

(1) *Chemistry of Combustion.*—It is very necessary at the initial stage, in considering the practical cures for black smoke, to place before the reader a few facts on the chemistry of combustion, because black smoke is the result of imperfect combustion. The writer does not claim to be a chemist, but merely to place on record what chemists tell us is true in regard to combustion. The assertion has often been made that the consumption of black smoke causes the emission of something, though invisible. This is as true as would be the statement that the colourless gas resulting from the perfect combustion of an oil lamp, or a gas burner, is more injurious than the smoke they make when out of order. Those who make this assertion should try the simple experiment for themselves by turning the wick of the lamp too high, or taking off the burner of the gas pipe, or holding a plate or other flat object in the gas flame. Smoke will at once begin to cloud the air, of a density depending on the size of the flame, and to the extent to which it is interfered with. We are told that the

lightest smoke consists of the same substances as the darkest, but the difference is in the proportion of the mixture. The bulk of all funace smoke, light or dark, is colourless carbonic acid gas, the same gas that we exhale, and no more injurious, and in this float the particles of soot, which alone constitute the visible part of smoke. It is the number of these particles in a given volume of smoke that determines the density and shade. Each particle is as black as its neighbour, and the result on the atmosphere is the same, whether they come in occasional crowds, or in a thinner or more continuous stream. The aggregate bulk in the densest smoke is as nothing compared with that of the gas in which they float, and of which, if combustion in the furnace had been complete, they would have formed part.

The black or solid particles of pure carbon, of which coal consists to the extent of about 90 per cent., are distilled from the coal as constituent parts of a gas when a certain temperature has been reached. They then form a chemical combination with the oxygen of the air, developing in so doing intense heat and light. Here the change is taking place from carbon and oxygen into carbonic acid. The particles which fail to obtain the necessary oxygen, when a combination heat, cool down, and appear as smoke. The solid incandescent fuel is not hot enough again to raise them to combination heat, so that when once formed they cannot be consumed. If there is sulphur in the coal, there will be sulphurous acid in the products of its combustion. All coal contains sulphur, varying from ½ to 1½ per cent. The emission of the sulphurous acid, therefore, does not depend on the blackness of the smoke, but on its presence near the ground, where it produces mischief largely. The soot being highly absorbent and heavier than the air, falls and brings down the sulphur gases it has absorbed, thus counteracting the natural tendency of those gases to ascend given to them by the heat to which they have been raised. The acids not thus brought down to earth are rapidly diffused and harmlessly diluted. The soot arrests much of this diffusion, concentrates the poison, and by settling with that poison on vegetation causes the fatal acidity always found on the bark of trees when covered by soot. Though soot has a value as manure when applied to the roots of plants, being carbon, and containing ammonia, yet when carried by the air it chokes the pores or stomata of the leaves, whose office is to obtain from the air the supply of carbonic acid gas on which the life of trees depends, and from which the carbon is obtained, of which wood and coal, which once was wood, chiefly consist.

The leaves perform the function much in the same way as the tissues of the lungs of animals obtain for the blood the oxygen of the air. They may be called the lungs of plants, and are suffocated by a covering of soot almost as effectually as we should be by a wetted cloth over our faces, or a coat of paint over our bodies. Though the carbonic acid is the food of plants, it is, however, a deadly poison to animal life, though in a lesser degree than sulphuric acids are poisonous to both animal and vegetable. Animals cannot breathe long when carbonic acid is present to the extent of 1 per cent., and 3 per cent. is soon fatal to them. Such, however, is the rapidity with which all gases diffuse themselves in one another› that all the carbonic acid made by the furnaces of the greatest of the manufacturing centres failed to make any addition which chemical analysis can detect to the natural proportion in which that gas exists as an element of the atmosphere. This proportion is 4 in 1000. The closeness in a crowded or ill-ventilated room is due to the presence of carbonic acid, and the absence of oxygen. The pungent taste of a yellow fog is largely due to the sulphur acids. The particles of soot hold the sulphur acid in the same way as the particles of condensed mixture, which constitutes the fog, hold in the air. In the absence of the soot and the fog, the sulphur acids would be imperceptible. The soot, then, must bear some of the odium attaching to the sulphur gases, whose harmless diffusion in the air it prevents.

(2) *Coal and its Consumption.*—Having looked at a few facts relative to chemical combustion, it will now be incumbent upon us to briefly examine coal consumption, and how consumption is brought about

in the furnace. To procure complete consumption of the coal in the furnace is a more difficult task than some imagine. Certain conditions must be carried out; if not, then consumption in its entirety will be impossible. Let us glance for a moment in the furnace, and, if possible, find out the process which is being carried on by the burning of coal.

After a fresh charge of coal on a briskly burning fire, what takes place? The coal softens, swells, and then follows the evolution of a large quantity of carburetted hydrogen gas, which requires air to bring about complete combustion. Furnaces after firing require double the quantity of air to what they require at other times, and unless the proper quantity is admitted to the furnace at this particular juncture, ignition or burning of the gases cannot take place, then the formation of smoke and its emission into the atmosphere. About 150ft. of air are required to burn 1 lb. of coal, and this air to burn the coal gas must pass over the fire. The gas first evolved from the fire by heat is carburetted hydrogen, and the non-formation of smoke depends entirely on the complete combustion of this gas. If there is an insufficiency of air passing through the furnace, then the carburetted hydrogen is unconsumed, and having a greater affinity for oxygen than carbon, it seizes on the oxygen present, leaving the black carbon which is emitted unburnt in the nature of black smoke.

It is calculated that 1 lb. of coal burned to carbonide oxide is theoretically capable of evaporating 4 lb. of water from 212 deg., whereas 1 lb. of coal thoroughly consumed and burned to carbonic acid will evaporate 13 lb. of water from the same degree of temperature.

For coal consumption and the prevention of black smoke the conditions, or rules to be observed, are four in number, viz.:—

(1) Ten volumes of air are required for each volume of gas evolved from the coal.

(2) Air and gas must be thoroughly mixed together.

(3) They must be heated to the point of ignition before passing the bridge wall.

(4) There must be room in the combustion chamber behind the bridge for the expansion of flame and the increased temperature.

If a complete consumption of coal is to take place, then these conditions must be carried out in their entirety. To do this, a little labour, care, and consideration will be entailed, but the results from every point of view will amply repay the trouble.

CHAPTER V.

AIR IN THE FURNACE.

In considering the chemistry of combustion and coal consumption, we must come to the conclusion that air plays a very important part in preventing black smoke. Air is absolutely essential in the furnace to cause combustion and give the necessary ignition to the gases. There are many people even to-day who believe that air, no matter of what kind, let into the furnace, does injury to an alarming extent. We feel sure such beliefs have no foundation in fact, but are superstitions which have grown up with their originators, who have never cared to go to the trouble to ascertain whether such assumptions were true. We admit that too much air allowed to enter a furnace will do injury, and prove very costly, yet, on the other hand, as air is the one essential with the coal to generate heat, the proper quantity will do the very opposite to injury to the furnace. There are numbers in charge of boilers and furnaces of various kinds who are resolutely determined to shut out (if it were possible) every particle of air from their furnace. No doubt they do this with the very best of intentions, being under the impression that they will obtain more heat, generate it quicker, and save coal in the bargain. But the very reverse is the case, as has been proved scores of times by expert engineers. Less heat, slower in its generation, more fuel consumed, and, as a natural consequence, a terrible nuisance in the form of black smoke, are the inevitable effects. We may safely say that it is now established beyond the question of a doubt that air is necessary for the practical prevention of black smoke.

(*a*) *Heat or Cold Air ?*—While there is a unanimity of opinion as to air being a requisite, there are differences of opinion, even amongst experts, as to whether the air shall be admitted into the furnace hot or cold. We have witnessed very many experiments in various furnaces, and under various conditions, with both hot and cold air. Hot air may, under certain conditions, reduce the density of smoke, if its temperature has been ignition point. But such a temperature would be difficult to obtain before entering the furnace. In spite of all some men claim for it in theory, in practice, by experiment, it has not in the slihgtest degree come out satisfactorily. One would naturally think that by putting hot air into the furnace, the temperature would be increased, that all the carbon in the coal would be consumed, and that there would be no smoke and a great saving. It may seem so on the surface, but it is not so in actual practice. Why, we will leave for the experts to settle among themselves. It is not our purpose to enter into any speculation, but to deal with the actual facts as brought before us frequently. And what do we find? That cold air answers the best. Instead of reducing the heat, it increases it, causes more rapid generation, saves fuel, and creates no nuisance. This is daily being exemplified in thousands of cases, though cold air seems to point to opposite results. If we want an outside, unmistakable, positive proof of the results stated, we have only to compare our house fires in summer and winter. The fires in summer, when the air is warm and sometimes hot, burn very sluggishly, and if not constantly forced, the heated atmosphere or air puts out the fire. There is no denying this fact, because we are daily confronted with it. So we might at once conclude that hot air is not very conducive to fires.

But notice the contrast in winter when the weather is cold and the air is frosty. The fires burn briskly, almost too quickly, and the heat is intense. What makes the difference? Undoubtedly, cold air. There is no getting away from such daily demonstrations, which should, if we are wise, suggest the idea to enable us to arrive at some solution of the smoke problem.

The Amount of Air to be Admitted.—On the amount of air admitted into the furnace depends a great deal. (1) Complete combustion; (2) great evaporation; and (3) economy of fuel. This question of quantity is a very important one, and ought to receive far more attention in the future than it has done in the past.

The danger lies in the two extremes, too little or too much air. If there is too little, then we have incomplete combustion and black smoke; if too much, then follows a reduction of temperature in the furnace, and as a consequence a great waste of fuel. But how is the happy medium, or proper proportion of air, required to be arrived at? This is a very difficult matter to decide. No universal rule can be laid down, setting forth with mathematical accuracy the quantity of air to be admitted under any or every condition. There are so many things to consider. For instance, coal (quality and quantity put on the furnace), conditions of fires (clean or dirty), natural draught, and many other minor matters, which all have to be considered in coming to a decision. In regard to quantity, the safest and most reliable rule for guidance, and producing the best results, is to watch the top of the chimney after firing. First put on a given quantity of coal, let in the air, shutting off quickly to ascertain if all the carbon or combustible is gone. When gone, take the time of air admission. By this method the exact quantity of air necessary can be ascertained under any conditions whatever.

Having found out the amount of air needed, this rule can be relied upon, without any further attention to the chimney, if always the same quantity of coal is put on, and the same time being allowed for air admission. The results will then be always the same, exceedingly satisfactory.

By this simple rule a fireman will be able to gauge accurately the amount of air required in his furnace, though his coal and conditions of working may be constantly changed.

(4) *When ought Air to be Admitted?*—This is a question which some may say needs no consideration whatever, for all are agreed that it must be admitted after firing. This is perfectly true, but there is much difference of opinion as to the duration of admission. This point we have already treated upon, under the head of amount required, and when not necessary its admission means a gross waste of money, both directly and indirectly. It would be of no use to admit it, say, five or eight minutes after firing, because by this time all the unburnt carbon would have passed off into the atmosphere in the shape of black smoke. There is then no doubt about it—the time most opportune to admit it is instantly after firing.

When ought air to be admitted? This is a question on which there is the greatest possible difference of opinion, even amongst those who have given many years to the study of this question, and whom we may safely say are looked upon as experts on the smoke question. When doctors differ, who can decide? This difference of opinion may be explained by the various experiments different men have made under different conditions, each admitting air in different ways, the result in each case being fairly satisfactory. This has led each experimenter to claim that his particular way, or a particular part of the furnace, is the only place where air ought to be admitted. One may be partially right when he says, if air is let into the furnace at a given point, satisfactory results follow, and another partially wrong when he says his is the only way to introduce it with good results. The two principal and most popular places for admitting the air are (1) at the door, and (2) at the bridge. Much might be said in favour of, and even against, each system. Then there are others who say that all the air ought to go through the bars.

Air going through the Bars.—This system of supplying the air to the furnace is a very good one. Being drawn through the fire, the air mixes with the gases, and rapid combustion is the result. This method works well while the fires are clean, but when the bars are covered with clinkers and require cleaning, the meshes in the bars are made up and air is excluded, then the system is practically useless. Hence some other means are necessary, which will not fail under any condition of working.

Air Admission at the Bridge.—The hollow, or split bridge as some call it, is a very old method of admitting air. The bridge may be of brickwork, or a metal box, placed at the end of the fire-bars, with an opening or door under the bars, to which door a rivet is attached by which the door can be opened or closed at the will of the firemen. Air passes under the bars, through the door, up the split bridge into the tube, and meeting the gases as they leave the furnace, causes the ignition of the same.

The survival of this system for so many years speaks somewhat strongly in its favour. It does stop the black smoke, either by burning it, or so thinning it as to make it almost imperceptible to the naked eye. Some authorities on combustion say, "Smoke once made cannot be burned or consumed." If such be the case, then the bridge, the place where the air is admitted, is the wrong place, because admitting it there puts it beyond the possibility of causing combustion in the furnace, as the air is let into the tube beyond the furnace, and if by meeting the gases or unburnt carbon coming from the furnace it does not cause that combustion which some claim for it, it does most certainly greatly diminish the density of the smoke and largely prevent a nuisance.

Many take objection to air going into the furnace at this particular point, not only on the grounds stated, but because it has a tendency to destroy the draught in the furnace. If the opening in the bridge is large, the greater portion of draught goes through it, causing an insufficiency in the furnace to generate the necessary heat. Thus there is a division of the draught, the air being taken through the bridge to burn the smoke, which ought to go through the fires to generate heat and evaporate water. This crippling of the draught is perceived more in boilers where the natural draught is only moderate, but, on the other hand, where there is plenty of pull on the boiler the division of it is barely recognised. It does not interfere with the fires in the least, stops the smoke, and is so far satisfactory.

Air Admission at the Door.—This seems at the first sight the most sensible system of air admission. If air is required to produce combustion—and we hope we have proved beyond the question of a doubt that it is—then it naturally follows that the air must enter the place when combustion (if there is any) must take place, and to enter the furnace it must go through the door, through and over the fire, igniting the gases while in the furnace. The more this system is considered the more scientific it seems, and the general adoption of the system of letting it in at the door during the whole of this century, and even from the very time when combustion was first considered, up to the present time, speaks for itself as to the success of the method. Boilermakers always put on the doors of their furnaces grids, circulars, or some other kind of opening, to be under the control of the fireman, through which air is let in. By this showing the door is the proper place for the air to enter. Very often these grids or openings are too small for the requirements of the furnace, and the fireman is constantly called upon to supplement the grid air admission by leaving open the door a minute or two. This system, though simple—and may be called by some antiquated and out of date—is most successful in preventing smoke, in efficiency, and going further (if properly worked) in economy. If black smoke is coming out of a chimney as thick as is possible for a chimney to carry, by letting in a little air at the door the blackness in a few seconds disappears. It goes from the top of the chimney instantaneously, as though cut off with a knife, thus proving its efficacy in killing black smoke. When other costly and complex systems fail the fireman always resorts to the door, which he finds to be a reliable friend to help him out of his difficulty.

(5) *The Question of Draught.*—Defective or insufficient draught is, beyond question, one of the causes of black smoke, and there is no disputing the fact that sufficient draught, in conjunction with other things, is one of the certain cures. The draught question as affecting boilers and furnaces has not received the attention its importance demands. Many manufacturers do not and will not build their furnace and boiler chimneys more than half the height absolutely necessary for the draught required. It means a little extra cost when building, but is a great saving in the end, to put up high chimneys, as the increased draught burns all the gases instead of wasting them by emitting them into the atmosphere, thus causing a nuisance. It is also very essential to have large flues in order to prevent black smoke. Spacious flues and a tall chimney are the two essentials for creating plenty of draught.

There are two kinds of draughts—natural and induced or forced. Of forced draughts there are many kinds (to make up for small chimneys and flues), which we shall deal with in detail later on. In natural draught, caused by the chimney, there is a uniformity or equality of pull which operates on every part of the fire, causing the fires to burn regularly, and expansion and contraction, proportionally with complete combustion, over the whole area of the furnace. Natural draught can be accurately regulated to suit the requirements of the boiler by the damper, and for the working of such draught there is no cost.

The disadvantages of insufficient draught have been dealt with, and we will now proceed to notice the advantages to be derived by having a keen draught. (1) A commoner and a smaller class of coal can be used, and burnt with profit by having plenty of pull on the boiler. (2) The generation of heat, or evaporation of water, is more rapid, which means more work done in a given time. (3) Then there is less labour for the fireman, by not having to constantly be poking, dragging, and clearing his fires. This is a considerable advantage to the fireman, as well as to the employer. (4) There is also an absence of black smoke, which means carbon consumed, and not wasted.

Plenty of draught produces efficiency, with much economy, and it is one of the chief factors for curing the smoke business.

(6) *Plenty of Boiler Power.*—The need of plenty of boiler room for the storage of sufficient steam to meet the demands at all times made upon the boiler is another very important matter which ought to receive the serious consideration of steam users. Many writers on this smoke question have contended that if manufacturers would only provide sufficient boiler power for their work there would soon be an end to the smoke nuisance from boiler chimneys. With this contention I entirely agree, for with enough boiler power there would be no necessity to unduly force the fires. Some have gone so far as to say that boiler capacity is the very best smoke preventer known. There is much force in such a statement, because every practical engineer knows what follows if the boiler is under its work, as I have pointed out in my remarks on the shortness of boiler power. To procure this boiler power is not an easy matter to some manufacturers. There are difficulties of many kinds to overcome, quite apart from those of a financial character. However anxious manufacturers may be to comply with all reasonable requests for preventing a nuisance, they are compelled to go to work gradually in order to remove these difficulties. To the outside and unpractical mind there may appear too great and unnecessary delay. To such we would call attention to the fact that boilers are not made in a day. It also takes time to fix them and fit them up. A convenient time has likewise to be waited for before the works

can be set down, and last, but not least, the cost is not a matter of a few pounds but of hundreds.

(7) *Sensible Stoking.*—There is, beyond the shadow of a doubt, much irresponsible stoking, and when this is the case there is bound to be black smoke, even if all the other essentials named for its prevention are extant. It is no use stoking when a furnace or fireplace is choked, or crammed full of coal, and this is no unusual thing even in this day of technical education and enlightenment. The time has now arrived when stokers are called upon to use a little common sense in their firing if they intend to effectually prevent smoke. We have pointed out six things as being absolutely essential in the practical prevention of black smoke. The necessary information may be supplied, and the proper conditions of working provided. Yet black smoke prevention depends entirely on the man at the wheel—the fireman. He can at his pleasure make or prevent it, as he is the person who puts all the other conditions named into operation. Many say, and say truly, that a good sensible stoker is the very best automatic smoke preventer extant. In fact, every smoke preventer now on the market owes its measure of success or failure largely to the treatment it receives at the hands of the fireman. This being so, the position of a stoker is a very important one, and his work being most skilled work, requires both a head and a hand. At one time the only qualification for a fireman was strength of arm to throw

on the coal. That day is now past. Strength, it is true, is necessary, but intelligence is more so. Neglecting the fires, losing the water, rising of the steam, sticking of safety valve, and a score of other things, if not quickly detected, might result in a very serious explosion, endangering not only the stoker's own life, but the lives of hundreds of others working in close proximity. The more one realises the responsibility attached to boiler firing, the more necessity there is for intelligent, sensible, steady stokers. If masters will not take steps to secure men of intelligence for the work, then it will be necessary for the public safety alone that the Government by Act of Parliament make it imperative that none but competent persons shall be allowed in charge of boilers, and for each contravention a heavy penalty should be imposed. This would create a class of men suitable for stoking.

Light firing, and often, is the best and most scientific system. The coal should be thinly spread on the incandescent fuel. Thus igniting the gases quickly, and complete combustion follows. There are different ways of firing lightly. Some work the fires a little thicker from the front towards the bridge, thus giving the gases a chance of igniting before passing over it. Others fire in the front of the furnace, and when the fuel becomes incandescent they push it forward, and by so doing always have a hot fire at the back to burn the gases passing over before leaving the furnace.

Some stokers will work a thin fine, say, 4in. or 5in. in thickness, and they find it, by thin quick firing, to answer their purpose admirably. Then there are others who have proved that a quick fire between 8in. and 10in. in thickness, is most suitable for their conditions of working. They do not fire thickly, but thinly, yet by firing often they get an incandescent body of fire sufficiently thick enough to answer their purpose. Either of the systems named (if the firings are light) are very good in preventing black smoke, combined with rapid evaporation, and efficiency. The best, most reliable, and safest system for complete smoke prevention, with efficiency, is what is known as the light alternate or side firing.

The stoker fires one side of the tube first; the gases curl, or turn round to the other side of the tube where the incandescent fire is, and the gases are at once ignited. Thus complete combustion takes place in the furnace where it ought to. If the fireman is in charge, say, of three Lancashire boilers, he first fires the left side of each tube of each boiler, and by the time he has finished firing the sixth tube, all the gases in the first tube will be consumed, making the left side of the tube an incandescent mass of fire. Then he proceeds to fire the right side of the tube of number 1, the left burning off the said gases. By this system of side firing, black smoke is a thing impossible. It is the very best possible system, and produces the very best possible results. It is a system which cannot fail, all other things provided. There is one thing, however, that militates greatly against the universal adoption of this splendid system, and that is the little extra labour which it makes for the stoker. This labour could be reduced by taking one boiler from his charge, and under this system we are almost safe in saying he will make more, or as much, steam with the two as he would with the three under the old senseless system of firing. There could be no reasonable cause for objection, either by master or man, to the adoption of this method, and there is no doubt that as a result the atmosphere would be purer. The furnace must, as far as practicable, be kept clear of clinkers if the fires are to burn briskly. No fixed period of time can be allowed for the working of the fires without cleaning; the times must vary considerably, as there are many things to take into account, such as the quality of the coal, forcing the fires, and many other matters which the fireman must consider, and clear his fires of clinkers accordingly. This is a matter often neglected, and is responsible for much dissatisfaction in the working of boilers.

Lighting Up.—There are many stokers who think they have a licence to make as much smoke as possible when lighting up their boilers. They will go further, and say that it cannot be prevented. In lighting up, a little black smoke must be made until there is sufficient heat in the furnace to prevent it, and this heat can be procured in thirty or forty minutes at the most, after which black smoke can be prevented by the heat generated. There is no necessity, even when getting up steam, to belch forth for two or three hours dense volumes of black smoke, because by ordinary care, as at other times, the emissions can be considerably reduced. There are firemen who do, when lighting up, use very great care in firing, and make very little smoke, which is proof positive that much can be done even under the greatest difficulties.

Classes for teaching practical coal combustion are absolutely necessary, and ought to be held in connection with the technical schools. The importance of such a subject demands it, and the wonder is that such classes have not been established before. There are classes for the steam engine and boiler; but complete coal combustion, and how to procure it, is seldom or ever touched upon. The varying conditions under which boilers are worked make the subject a very difficult one, yet not too difficult to overcome, as there are scores of persons who are experts on this question, and who would be able to teach men who were willing to become boiler or furnace firemen. Considering there are no special facilities for procuring information on this question, by those who are desirous of information on the subject, it is a wonder matters are not worse than they are. It is unreasonable to expect a man, when put in charge of a boiler without any special training, to work it satisfactorily. The knowledge necessary will not descend upon him in his dream, but must be imparted to him by those who have had practical experience in the work. If persons in charge of boilers and furnaces, and those who intended to take up that class of work, refused to attend classes, then it would be necessary to send an instructor to the various works, where needed, to show the men how to fire in the very best possible way. It would be profitable for a number of manufacturers to engage an expert on this question, for the purpose of teaching their firemen, continually watching them, and insisting that the rules laid down were carried out. Special tuition in stoking at our technical schools, or at the works, is now imperative, if we are to have a class of intelligent and industrious stokers. Without this class of men black smoke is bound to be made. As I have pointed out, everything is in the stoker's hands, and on his applied knowledge depends the results which follow, whether beneficial or otherwise

CHAPTER VI.

SMOKE-PREVENTING APPLIANCES.

THE admitted necessity of mechanical appliances designed to solve the problem of smoke prevention has given rise to a large number of inventions of varying degrees of merit, and in order to be, if possible, of some little service to manufacturers in selecting the very best, in regard to simplicity, cheapness, and effectiveness, I purpose describing some of the machines which I consider the very best on the market, mainly selecting for the purpose those which have been before the public for many years, and which have stood all kinds of tests, and have been found fairly satisfactory, are extensively used in all kinds of trades, and are to-day in great demand.

It must be borne in mind that it would be impossible to deal with all the admirable appliances now in the market, and I have therefore selected a few of the most representative, in order that the public may have some slight idea of what they are in principle and what they may be expected to do in practice.

Grids, Panels, Louvre, or Circular.—We have already said one or two things about grids, under the head of air admission, yet there are many more points in regard to them which might with profit be now considered. The panel, louvre, or circular are similar to the grid. Each is for the purpose of letting in air, and each is shut by the stoker when air is not necessary. This apparatus or arrangement is very old. Its exact age I am not in a position to state, but it must have had its birth at the very commencement of the smoke-consuming crusade. While very many smoke-consuming children have made their advent since, and only survived a very short time, the grid is with us to-day—a fact which speaks well for its merits. There are multitudes of men who tell us there is nothing superior to it for simplicity, efficiency, and success. It is applied in the first instance to every class of boiler, and could with similar success be applied to the various kinds of other furnaces. There is no necessity to particularise its working parts; they are so few and so simple that we are all acquainted with them. Often the grid is not large enough to admit the air needed in the furnace just after firing, but this is a small matter which can easily be rectified. There is one other fault which so often proves fatal to it, namely, its non-automatic action. It will not work itself. The fireman often allows the slides to get fast with tar or dirt; sometimes he will work them, and at others he forgets to work them, and often he will not work them; then the grid is condemned because it will not work itself.

We are daily coming in contact with experienced firemen and engineers who say they could not wish for a more simple and more satisfactory arrangement when worked, and the only thing wanted is a simple, reliable, automatic device to close the grids at one or more minutes, thus taking away from the firemen the responsibility. They say if this were done the grid would become more popular, and more successful in preventing smoke than it has ever been.

THE AUTOMATIC REGULATOR.

The patentees claim for this invention complete consumption of smoke, and in its application to steam boilers it effects a saving of from 15 to 20 per cent. It is simple of construction and self-acting. The diagram (Fig. 1) exhibits the apparatus as applied to a Lancashire steam boiler. An opening is provided for the passage of air in the lower part of the bridge below the fire-bars. This opening is fitted with a door or valve, which is opened and closed by a rod or chain brought to the front of the furnace. The end of the rod or chain is connected to a lever or wheel fixed to a shaft placed across the lower part of the furnace front. On the shaft there are fixed two levers, one of which is actuated by a corresponding lever, attached either to the fire-door or to its hinged butt, so as to allow of the fire-door being opened for the stoker to examine the fire, yet not wide enough to allow of firing without the levers coming into contact. When the fire is fully opened for firing up, the levers cause the shaft to turn open the door or valve in the lower part of the bridge. At the same time a connecting-rod attached to the second lever on the shaft is set in motion and actuates a beam or lever, or series of levers, communicating with a specially constructed apparatus, hereinafter referred to as the regulator. It is this

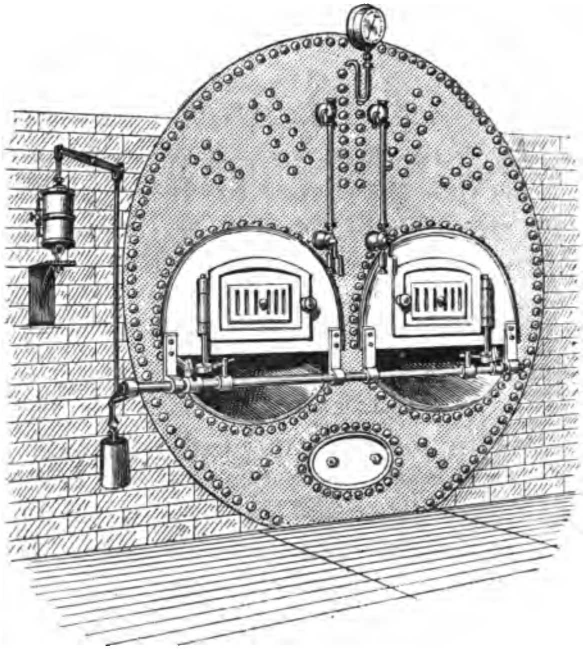


FIG. 1.—THE AUTOMATIC REGULATOR.

regulator which forms the essential feature of the invention, combined with the arrangement and combination of parts by which it is brought into action.

The regulator is a cylinder fitted with a bucket or plunger provided with a valve, the end of which is attached to the beam or levers previously referred to, which are actuated by the opening of the fire-door. The cylinder is filled with glycerine, oil, or other suitable fluid, and provided with a port or passage from the top of the cylinder to the bottom. On this passage there is a cock, or cocks whereby the area through which the fluid has to pass may be varied according to the time it is desirable for the regulator to occupy in its action, which is as follows:—When the stoker opens the fire-door for firing up, the bucket or plunger is forced down to the bottom of the cylinder, the fluid contents rising through the valve to the opposite end of the cylinder above the plunger. When in this position, if the communication between the top and bottom of the cylinder is entirely closed, the apparatus will remain stationary, but on the passage being opened by means of the cock or cocks previously referred to, the plunger actuated, as it is by the weight of the moving parts already described, or by a counterpoise in the form of a spring or balance weight, begins to ascend in the cylinder, and continues to go up as rapidly as the orifice through which the liquid has to pass will allow, this upward or return motion of the plunger causing the door in the fire-bridge to close. In some cases the cylinder is so fixed that it will oscillate so as to accommodate itself to the radial movements of the lever or beam, consequently there is no necessity to employ a connecting-rod, slide, or parallel motion. When the regulator and its mechanism have once been adjusted and connected to the door, through which the air to the bridge of the furnace is admitted, it is impossible for the stoker to throw fuel upon the fire without opening the door, and having been opened, it can only be closed by the action of the regulator, and by means of the cock or cocks. The motion of the regulator may be timed at will. By providing the cocks with a removable key, or by placing them on the regulator in a lock-up case, the regulator once set cannot be tampered with. An important advantage connected with this invention is that the necessary appliances can be fitted without drilling holes through the plates, and no steam jet is used or required. By the detailed and somewhat lengthy description of the action of this arrangement, the reader (without further illustration) will be able to comprehend its construction.

We have already referred to the hollow bridge as a means of admitting air into the tube. Such an arrangement was in existence as far back as 1820, but the door of the bridge was originally opened and closed by a rod worked by hand. The bridge is the same in construction, and the rod is the same kind, but the patent consists solely and wholly in the automatic action, thus taking out of the hands of the fireman the responsibility of opening and closing the bridge door. There are four parts which may easily tell against the efficient working of the apparatus.

(1) By admitting air through a hollow bridge there is a danger of destroying the draught in the furnace. (2) The draught pulls the ashes and dirt into the bridge, and very quickly makes up the aperture, and unless cleaned out regularly it renders the bridge useless. (3) We often find that firemen leave in the tube the ashes until they are nearly up to the bars. This is done in some cases wilfully, and in others by thoughtlessness. (4) The rod by which the door is worked gets excessively hot, and very quickly loses its original shape, the heat bending it into various shapes, which make it useless for the work it has to do. If these conditions do not exist, then we can safely say that the apparatus will, if properly regulated, prevent black smoke.

Steam Jets.—The introduction of steam jets into the boiler or heating furnace is a very old idea, yet not the less valuable because of its age. They were designed for two purposes, namely, to increase the draught, and as the firemen would say, "to kill the smoke." It was in boilers where the draught was insufficient that the jets were introduced. They were put through the frame of the furnace, just above the door, and blew the steam and blast on the fires; which generated heat and steam much quicker than could be done without them. These jets were kept blowing continuously, thus increasing considerably the duty of the boiler. The cost of steam was a mere trifle compared with the amount of extra work done.

The jet was also found to answer a dual purpose, as it not only increased draught, but destroyed the smoke. To do the latter it was found necessary to leave either the grids or the firing-hole door open a few minutes after firing, so as to admit the necessary air to ignite the gases. When this was done there was an absence of black smoke with efficiency. This simple system by its successful working became very popular, until by neglect in the working of it, it gradually died, and was superseded by other things more costly, and often not so successful. After being buried for many years, it has had a resurrection, and to-day is found almost everywhere. The principle is the same, but it is applied in many other ways. I purpose dealing with these later under another head.

Hollow Bars.—Hollow bars, like the hollow bridge, have been in use for a very long period. They admit the air into the tube at the same place as the bridge, and with similar results. To illustrate this system I propose introducing to my readers' notice a very old bar which has been on the market for many years. The object of the tubular bar is to provide an auxiliary supply of heated air at the back of the bridge without robbing the grate of any air that ought to pass through it in the ordinary way. The air so provided mixes with the unconsumed gases and carbons passing over the bridge, and supplies oxygen for their ignition, thereby ensuring improved combustion, and reducing smoke to a minimum.

The tubular bar is 1in. wide. A wrought iron tube curved downward at the front end passes longitudinally through the bar, the bar proper being, indeed, cast round the tube. The face of the bar is slightly rounded, and by a special process in the manufacture, is made smooth, and chilled to the depth of ¾in. The bar is cast from the best mixture of metal face downward, thus ensuring density and hardness.

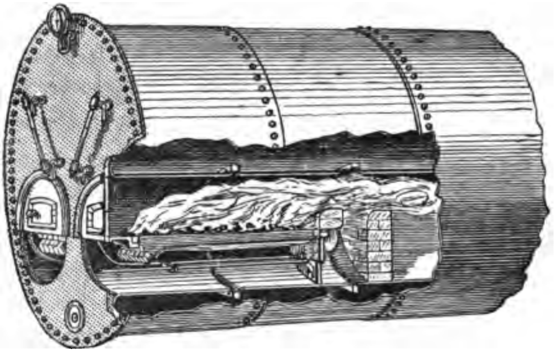


FIG. 2.—THE CADDY PATENT TUBULAR FURNACE.

The comparatively cool air from the stoke room enters the projecting and down-curved mouth of the tube at the front end of the bar, and passing through cools, and in return becomes heated by it, and is mixed behind the bridge, where, coming in contact with the unconsumed gases and carbon, it provides oxygen for their ignition, thereby not only relieving smoke, but securing improved combustion, and so economising fuel. The tubular bar is adaptable to all forms of fire grates, and can be fitted in a few hours, all drilling and cutting the flue being avoided. The patentees also claim for this bar abnormal durability, great strength, twisting and bending entirely prevented, by

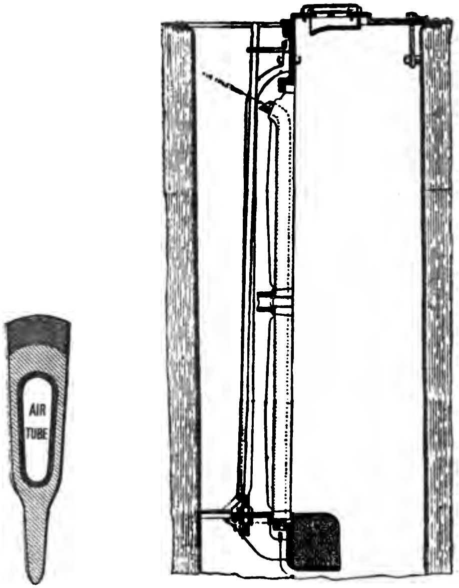


Fig. 3

the wrought iron tube cast through the bar, freedom from clinkering, less frequent cleaning of fires, permanently increased evaporative efficiency of steam generating plant, and a saving of from 10 to 20 per cent. There is sufficient promise (which, if realised in practice) to make the bar a perfect preventer.

The foregoing illustrations (Fig. 3) show a full-sized section of the bar, also the bar fitted in the furnace, enabling the reader to better understand its construction and the working of it. Since the introduction of this bar other hollow bars have made their appearance, practically the same in principle, but slightly different in a few details.

All that we have said about admitting air at the bridge, for and against, will apply to its admission through hollow bars. If the hollow bars are kept clean and the air passages clear, they will, beyond question, prevent black smoke, if the air admitted for the firing is sufficient; but from the manufacturers' point of view there is another thing, that is, to prevent smoke and generate steam with no loss. It is easy to talk of preventing smoke with a saving of from 5 to 50 per cent., much more easily said than done. Some experts on the question tell us that the very best results will not realise more than from 5 to 10 per cent. saving, and these are very rare cases. We find in these days that manufacturers are compelled to study economy, and many of them object to the hollow bar, because air is being continuously admitted into the furnace, which means from 60 to 80 per cent. more air going into the furnace than it requires, and with what result? Their coal bill has gone up considerably, and in spite of the hollow bars preventing smoke they have been in many cases abandoned. The remedy for this is very simple, all that is required being an automatic arrangement to shut off the air when not necessary. Then there would be prevention of smoke with economy. I do not know of a hollow bar superior, or even equal, to the Caddy bar (having stood the test for so many years) for simplicity, durability, and for all-round success.

DOUBLE DOORS.

The "Hydes and Bennett" patent is a door which has been adopted by a large number of firms, who have found it (when worked) to give very satisfactory results. This door is somewhat similar to other cast doors, with the exception of an opening in the centre about 8in. by 3½in., into which fits a plate, fastened on two pins in the centre, which allow the plate to be pushed forward for the admission of air, and closed when not required. In front of this moving door there is a perforated plate, through which the air passes into the furnace. This is a very simple arrangement, its working depends entirely on the firemen; but very often the firemen neglect working them, which renders them of no use. We very briefly call the attention of the reader to this apparatus, to prove that the simplest device, if only attended to properly, will be a successful smoke preventer; and without such attention on the part of the fireman, the best apparatus may prove unavailing.

MECHANICAL STOKERS.

There has been a gradual evolution in smoke consumers, from the Grid to the "Mechanical Stoker," a preventive which is a substitute for the man stoker. Man had so often neglected to do his duty that necessity brought into existence a machine, which fires the boiler regularly and automatically. There are very many mechanical stokers now on the market. Some are declining in popularity—or, to be truthful, they are practically dead; while others still retain their reputation for smoke prevention with efficiency, when carefully attended to.

I have selected three mechanical stokers of different types which will, I think, most fully and fairly represent the various kinds of sprinkling and coking stokers which are now working very satisfactorily in this country, and also in other countries, viz., the "Proctor," the "Vicars," and the "Helix." Public opinion concerning them unmistakeably places them in the above-named order.

Proctor's New System of Coking Stoker.—From the illustration (Fig. 4, p. 70) it will be seen that the coal is carried forward upon the ram, and on the return stroke is deposited upon the fire by falling off the end and sides of the ram. Thus the supply of fuel will be kept up by placing a layer of fuel upon the fire at one stroke, and skimming it forward by the next stroke, after it has coked; or, in other words, the coal is laid upon the fire in contradistinction to being pushed upon, or in front of the fire, as is usual in other coking systems; and in this consists the originality, principle, and action of this system. The rams have a quick inward and outward motion, and have a dwell of one-half a revolution amongst the green coal thereby preventing them getting hot. The ends which are most exposed to the fire are made detachable, so that they can be easily changed in two or three minutes, at a cost of about 9d. each; but they will not burn if kept supplied with coal and drawn out of the fire when the machine is stopped.

Why the Moving Bar is the Best.—(1) Self-cleaning is accomplished by inclining or giving the bars fall to the back and with a to-and-fro lever motion of alternate bars, causing the dross and fire to fall to the back by its own gravity, and the fall can be regulated by giving more or less traverse, and increasing the speed of the bars having three different speeds to vary upon.

(2) Alternate bar movement is found far superior to moving the bars altogether, which necessitates a very complicated piece of machinery, every bar having to be moved, as in moving forward altogether the bars have only separate action in the return stroke, whereas by moving every alternate bar there is double the chance of keeping the bars from soldering together, and also keeping the air space free, which is the main object in moving bars.

(3) This is the only patent with a steam bearer for protecting the bar ends, and which allows an active fire to be kept up the whole length of the bars, without fear of burning the backs down, if the steam is kept circulating through, whereas without the steam bearer the fire has to partially burn itself away before getting to the back, whereby reducing the effective duty at the back end of the bars.

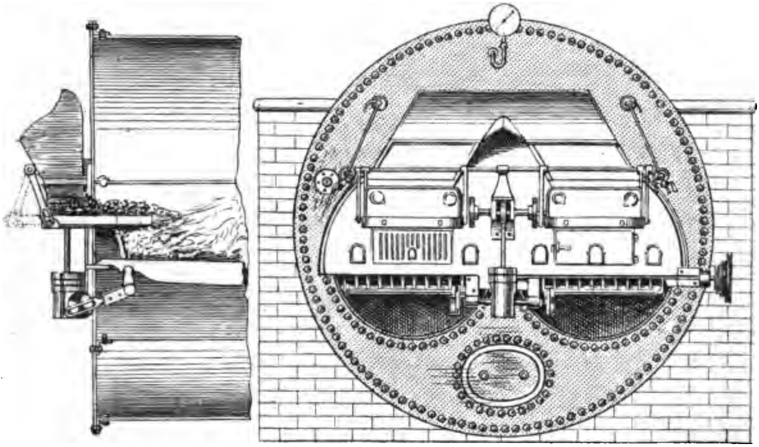


FIG. 4.—PROCTOR'S NEW SYSTEM OF COKING STOKER.

(4) Only a slight vapour of steam is required to issue from the jets, to show that it is circulating through the steam bearer, and not for the purpose of blowing the fire at the front, which makes a white-hot fire at the mouth of the furnace, and little or none at

the back. By having this intense heat so near the boiler front (the most rigid part), it cannot but have an injurious effect upon the same.

(5) It is simple in construction, takes very little power, and can be changed as easily as ordinary stationary bars. These bars can be used in three different ways, viz , as self-clearing bars, or they can be put in and out of gear to work intermittently, or as hand moving bars. The other advantages advocated on behalf of this stoker are:—All the coking is done inside the fires. Tiles or fire-bricks for coking purposes entirely dispensed with. Firing by hand can easily be resorted to. When the supply of fuel is properly regulated, the stoker will work two or three hours, and with reasonable load has worked for half a day without being interfered with. Working parts are few and simple in construction, and the highest efficiency is obtained, and also ample provision is made for Inspectors and firemen getting into the flues without taking the apparatus down.

The illustration (Fig. 5) shows a front view of the Vicars' new and improved 1896 patent mechanical stokers and self-clinkering smokeless furnaces fitted to a Lancashire boiler.

Fig. 6 shows an inside section of the stoker, which will help the reader to understand the mechanical movements. The mechanism of this machine may at the first sight seem to be very complicated and complex, but on examination of its construction and operation we shall find the stoker far simpler than it appears at the first glance. I will, in particularising the various parts endeavour to make the machine thoroughly understood by all. During the last few years this stoker has been improved in many of its details as undermentioned. The fuel, after leaving the charging boxes by the action of the reciprocating plungers, is deposited on a coking plate, where it lies in a mass of 12in. deep, and is thoroughly coked before being carried inward by the movements of the grate-bars.

The two separate mechanical movements in the operation of this stoker are driven by auxiliary power, are each independent of the other, and both entirely automatic in their action. They are the "coal feed and grate motion."

The coal feed is varied by altering the rate of revolution of the plungers, which by the simple movement of a shut lever can be instantly adjusted to a wide range of movement, from slow to rapid, as the consumption of fuel may require, the feed to each furnace being entirely independent of the other. The grate motion is a reciprocating action of the grate-bars, and is opened in the same way as the coal feed, but with several intermediate variations, from a state of rest to a movement of 3½in. The bars in each furnace are arranged in two sets, each composed of the alternate bars, which sets operate together in moving inwards, but return at separate intervals. Thus the fuel is carried inward by the simultaneous action of both sets of bars, and remain in place without being disturbed by the return of either set. Each successive inward movement of the bars

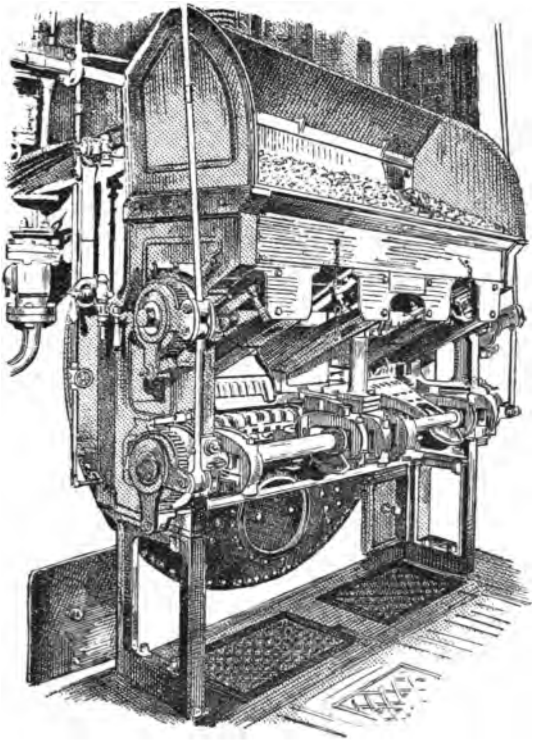


FIG. 5.—VICAR'S NEW AND IMPROVED 1896 PATENT MECHANICAL STOKER AND SELF-CLINKERING SMOKELESS FURNACES.

serves to carry the fuel, together with the clinker and ash refuse, nearer to the inner end of the grate, when the mass at length drops over into the combustion chamber, and forms and maintains a bank which acts as a bridge, and on which the combustion of the precipitated fuel is, in due time, completed. An ordinary "bridge wall," or "flame bridge," is built in the flue or setting, a short distance beyond the grate-bars.

The combined and harmonious actions of the coal feed and grate motion give the operator such thorough and continuous control of the quantity of fuel admitted, and the time it is retained in the coking arch and on the grate-bars, as to secure perfect combustion and the emission of smokeless gases.

The various parts receive their movement from an overhead shaft, which can be attached either to the stoker itself or to other bases of support. Doors are provided that can be used for hand-firing if desired, but as in regular service they are only used for banking fires, the usual cooling off due to the frequent opening of charging doors is entirely avoided.

(1) It is claimed that steam can be generated by the stoker from the lowest qualities of dross.

(2) By means of the feeding arrangement the gases are consumed in passing over the fires, and thus little or no smoke is emitted from the chimneys.

(3) By combining conveying plant with stokers a saving of 50 per cent. can be effected.

Often there is a decided difference between the statement of the makers of various kinds of smoke-consuming machines in regard to the saving effected

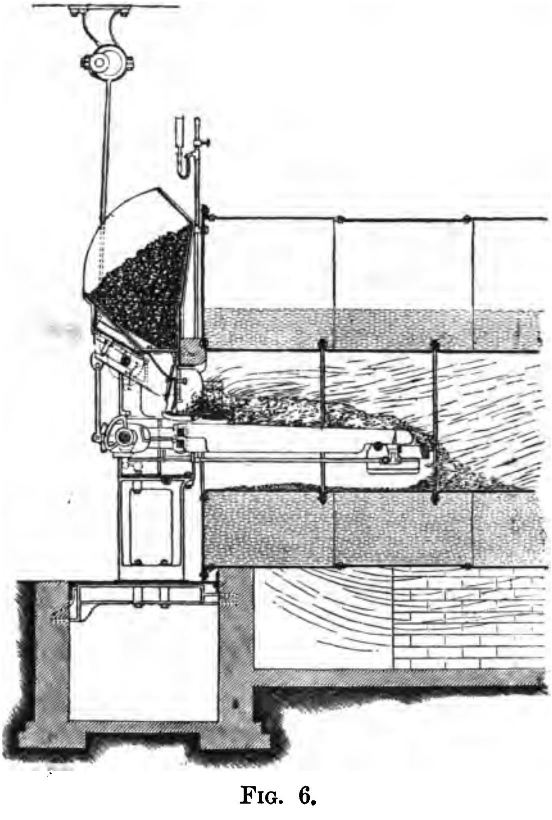


FIG. 6.

and the persons who purchase them. We do not intend to discuss these differences, but leave the machines to prove the actual saving in practice, which is the only way of ascertaining the merits or demerits of any machine.

The illustration (Fig. 7) below is a part view of a battery of ten Lancashire boilers, and introduces to our notice a stoker of an entirely different principle to those already considered, this feeding the fires underneath, while the others feed the fires at the top. The patentee of this new idea of feeding fires by a mechanical stoker says, "After many experiments worked out in many forms, and under all possible conditions, it is now well known that the way to prevent smoke is to supply the fresh fuel underneath and send it up through the fire or furnace of whatever kind it may

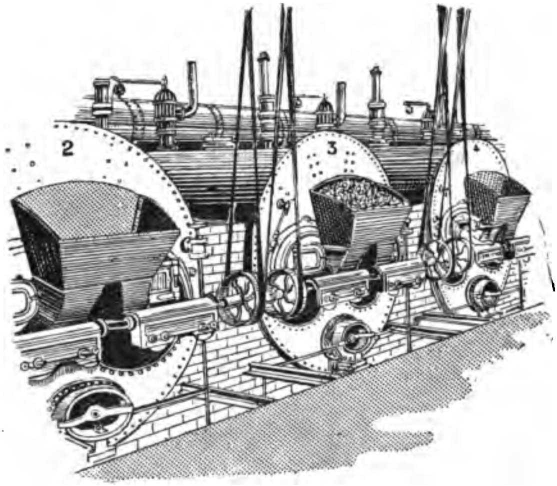


Fig. 7.—Andrews' Helix Furnace Feeder.

be. This consummation has now been attained only by the 'Helix Furnace Feeder.' All other mechanical stokers supply the fuel at the top of the fire, varying from one another only in matter of detail, but one and all following the exploded fallacy of trying to prevent or consume smoke while putting green coal on at the top of the fire. By throwing the coal over the surface of the fire in very small quantities there is in some cases an apparent diminution of smoke, but by careful examination it is found that this apparent or real reduction of smoke is only effected by carrying up the chimney small particles of coal and flue dust, which, while not so visible to casual observance, is a far greater danger and nuisance to the surrounding neighbourhood than smoke itself. By sending the fuel right through the fire, from the bottom upwards, on the principle of the 'Helix Furnace Feeder,' neither smoke nor dust nor sulphur can escape, perfect combustion of all particles must of necessity take place in passing through the body of the furnace, rendering the vicinity of chimney stacks, furnace piles, and manufacturing hearths of every description as pure and sweet and healthy as a gentleman's park."

Instead of the furnace floor consisting entirely of fire-bars, some are omitted, and in their stead two or more long troughs are placed and connected, and there are openings along the taper tubes, beneath the fire-bars. The wide ends of these tubes continue under the dead plate and join a feed trough or hopper box, which crosses the front of the furnace. Passing through the feed trough, and filling the taper tubes, long, auger-like screws are placed, and receive either an intermittent motion from ratchets and pauls, or a continuous motion from worm wheels and worms carried on a shaft running in front of the furnace. A large hopper supplies the coal to the feed-trough, and the screws carry it into and along the taper tubes, and fill it up through the openings previously described into the fire in proper proportions throughout the whole length of the furnace.

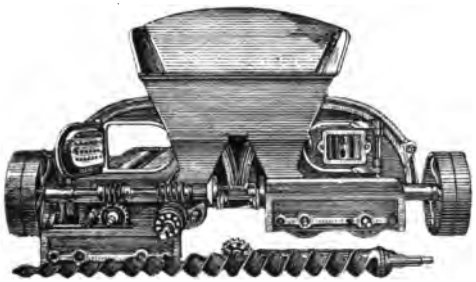


FIG. 8.—FRONT VIEW, WITH THE SCREW TAKEN OUT AND PLACED IN FRONT.

The accompanying illustration (Fig. 9) shows an inside view of the furnace. There are in this furnace the tilting bars, which are very useful for rapid and constant cleaning, when using dirty coal and pushed for steam. These bars are worked by hand from the front of the boiler.

The patentee says the following advantages are to be gained by using his furnace feeder:—"Absolute simplicity, notable economy, durability, applicable to all steam boilers, easy supervision, increased evaporation, smokeless, uniform feeding of the grate, and complete combustion." There is a great deal of force in what is said in favour of this furnace. The feeding of the fire underneath will ignite the gases, and give them less opportunity of escaping up the chimney, than many other systems of firing, either by hand or machine.

I have visited works where a range of ten Lancashire boilers were fitted with the "Helix Furnace Feeder," which on inspection with the chief engineer were found to be working fairly satisfactorily. The engineer said, "They had been working many years, and they had little cause for complaint."

I have no desire to imply for one moment that the three stokers named are the only stokers on the market which are successful as smoke preventers.

There are many excellent stokers which are slightly different to each other in some detail, yet one in principle, and which are doing splendid service—stokers to suit various conditions of working—that manufacturers might purchase with profit. Therefore, having such a variety of stokers to select from, smoke makers have only to take their choice and pay the price. The mechanical stoker is a fairly popular machine, and is very extensively used in various parts of this and other countries, especially by those unable to rely on sensible stoking by their firemen. The fireman has only to fill the hopper, and the machine does the firing, with a regularity, reasonableness, and results which the man often fails in.

The principle of mechanical stokers is an excellent one, viz., light-firing. In all the machines, without exception, the patentees are agreed that light and regular firing is absolutely essential for practical smoke prevention, and the sooner this principle receives that general recognition which it deserves the sooner we shall be rid of all preventable smoke. The great popularity which this class of machine has gained is due to the practicability of the principle on which the machine is constructed.

The mechanism of some of these machines is very complex, while, on the other hand, in others it is very simple. Experience teaches daily that the simpler the machine the more successful that machine is likely to work, if the simplicity is combined with efficiency. The more complex a machine is the more liable it is to get out of repair, and the more attention it requires at the hands of the fireman, which is all against it. All machinery, whether complex or simple, requires attention if it is to work satisfactorily and with great success, and especially mechanical stokers, because the mechanism is so exposed to the dust and dirt, not only when cleaning, but throughout the day, that unless they are well cleaned and oiled they will very quickly get out of repair. I have visited works where many stokers have been working, and it has been difficult to detect the various parts owing to there being so much dirt upon them. I have wondered at them working at all, let alone doing well under such conditions, and it speaks very highly of the merits of the machines. This is the point I desire to enforce most strongly here, viz., that all machines, appliances, or arrangements of any kind for the prevention of smoke must have reasonable attention at the hands of the fireman to get the best results from them. If this attention is not paid to them, the very best arrangement will be useless. I do not wish to speak too strongly on this point, but I am constantly called upon to face facts which warrant me in saying that firemen in many instances are responsible for the failure of appliances simply because they take an

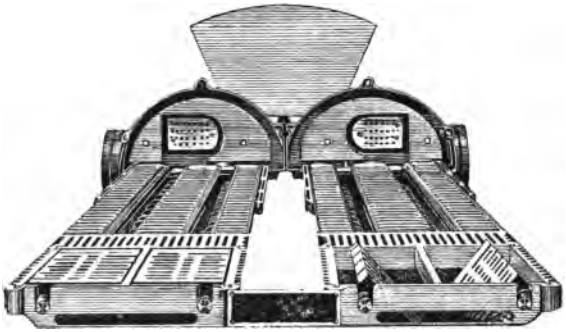


FIG. 9.—INSIDE VIEW.

antipathy to them, in spite of the fact that the employer has been satisfied the arrangement will do its work if properly attended to. In such cases the penalty or punishment should fall on the fireman.

Mechanical stokers work with uniformity and regularity if kept in condition and the fires are fed slowly or quickly with the required quantities. There is often attached an automatic damper which closes when the steam reaches a given pressure, and opens when the steam falls below that pressure. This is another great advantage of the stoker. The fireman can leave his boiler with safety for a great length of time to go and do other work, finding on his return the steam up and the fires in good condition. This prevents, on the one hand, a waste of steam or a dropping of the steam, and the setting down for a time of the machinery.

There is no doubt about mechanical stokers saving labour if they work well.

The initial cost of stokers prevents many manufacturers from purchasing them. To fit up a few boilers with them means a big outlay. Many maintain that the cost of working is rather heavy, while there are others who say the working cost is fairly small. Such opposite statements may be explained by the conditions under which they work, which makes running and repairing either a large or small item.

It may be asked, are stokers capable of meeting all working conditions? This question, we think, is definitely answered in the negative by the abandonment of series of stokers of every kind by manufacturers in our big cities and centres of industry. They find that stokers are of little use on boilers when the steam required is intermittent and irregular. Such boilers can be fired better by hand, with less labour and better results. Many have had stokers on boilers working under such conditions, and have been compelled to help with hand firing. The result has been taking off the stoker and firing by hand, which they say is more successful. This is not an isolated opinion, but is general amongst owners of rolling mills, presses, forges, hammers, and many other kinds of irregular work, who have had to pay dearly to find out the better system.

Stokers are very suitable and successful on boilers where the work and running is regular, viz., flour mills, spinning and weaving mills, turning shops, silversmiths, cutlery manufacturing, electric lighting, and, if necessary, we might mention many other trades, where the work is continuously the same, and on such boilers they invariably do well. Where we have positive proof that one kind (no matter how good) of apparatus will not suit every working condition, then it behoves steam users to select the preventer most suitable for their individual purposes.

WASHING SMOKE.

It may be of interest and benefit to the reader to notice what has been attempted in the way of washing smoke. Some time ago an apparatus was put on the market with this object in view. It was placed at the bottom of the chimney, and consisted of a fan with beaters, which ran rapidly round in water. The smoke passed into this apparatus, and the beaters were supposed to wash out all the unburnt carbon (which was claimed to be a good disinfectant), so that nothing but invisible gases passed up the chimney. It was a very costly arrangement; but this was not the fatal objection, as it cooled the gases and destroyed the draught, which made the apparatus useless.

Then there came along an apparatus (somewhat similar in principle to the smoke washer), which was called the smoke condenser. By this arrangement the ordinary chimney was dispensed with, the smoke being discharged into one or more tubes, and being met by jets of steam, which it was alleged "condensed it as it passed from one tube to the other," thus ultimately emitting steam and smoke of a lightish colour. This arrangement was tried at various times, but, like the other, it destroyed the draught. This very quickly died, although the patentee was very sanguine about its success. Possibly if the process could have been carried on without interfering with the draught, there would have been some prospect of its becoming popular as a practical smoke preventer.

FORCED DRAUGHT.

In the gradual process of evolution going on for many years in smoke prevention, we find that forced draught apparatuses have gained a great amount of public favour, and for the following reasons:—(1) Because there is increased evaporation; (2) they supply a deficiency of draught; and (3) a cheaper coal can be used. These three advantages have created such a rage for this kind of apparatus that manufacturers who have had plenty of natural draught on their boilers have adopted the forced draught, but only to find out they have made a mistake. Forced draught is necessary when the natural draught is insufficient, and in these cases it produces beneficial results. Like other kinds of preventers, there are a great many of them before the public, each slightly different to the other in some detail. In order to make known this forced draught principle of smoke prevention, we illustrate two kinds which have gained the most favour.

THE "MELDRUM FURNACE."

Fig. 10 is an illustration of Lancashire boilers fitted with the "Meldrum." The phenomenal success that has been achieved by this furnace is the best testimony of its intrinsic value, as there has been over 6000 furnaces fitted, representing over one million horse-power.

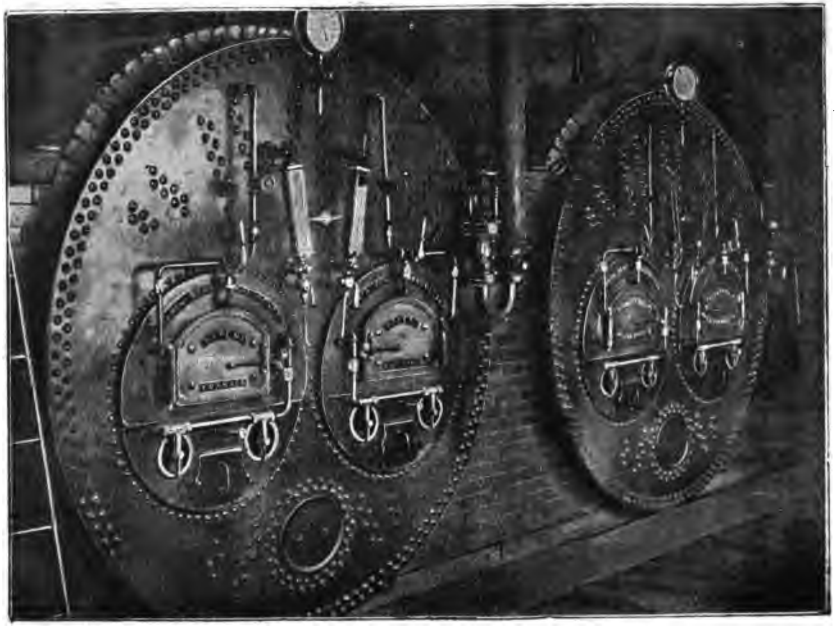


FIG. 10.—MELDRUM'S FURNACE.

In the adoption of this apparatus the whole air supply is under absolute control, so that the fire may be forced or slackened at will, and this entirely independently of atmospheric conditions.

The patent steam-jet blowers are a special feature of this apparatus.

The patent bars are made interlocking to prevent displacement, and are spaced about $\frac{1}{16}$in. apart to prevent anything but the finest dust falling through. The action of the steam and air on the bars prevents clinker adhering; the bars consequently last three or four times as long as ordinary bars with natural draught.

In this system the steam for actuating the blower is first superheated and perfectly dried. This is a very important point, as by this means the efficiency of the blower is materially increased, and all danger of moisture in the boiler flues is overcome. The illustration (Fig. 12) shows clearly the method adopted, and also the patented arrangement of valvular dead plates for the efficient consumption of smoke. By use of the Meldrum furnace a great saving is generally effected, not only by burning inferior fuel, but also by being able to maintain steam more regularly, and with less forcing to the boiler. This furnace is specially designed for low-class fuels, such as coal dust and coke dust, &c., which can be burnt with good results when the bars are close and the air supplied under considerable pressure, much beyond the power of chimney draught. This pressure does not extend further than the ashpit and through the fuel, which is just the place required to effect perfect combustion, and produce a high temperature flame. After passing over the bridge, the flame and hot gases travel through the boiler flues at the ordinary rate of chimney draught.

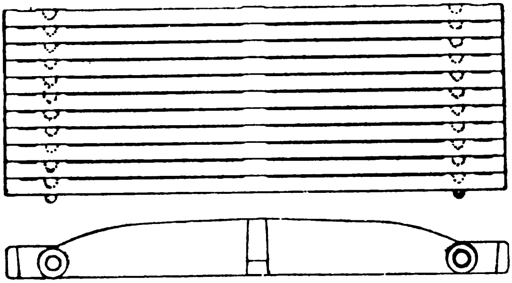
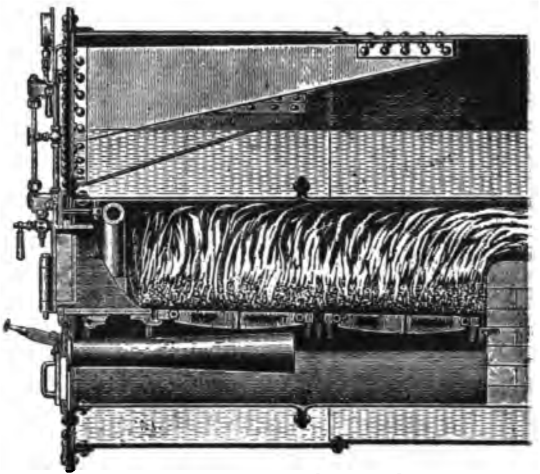


Fig. 11.—Elevation and Plans Interlocking Fire-bars.

The illustration (Fig. 12) will give the reader a correct idea of the result in the furnace by the action of this apparatus.

The patentees also claim for it the following advantages: — (1) Increases the draught where deficient. (2) Any kind of inferior fuel can be burnt. (3) The evaporative power of the best coal increased. (4) Clinkers are prevented from adhering to the bars. (5) Fire-bars are preserved, and last for years. (6) No liability to get out of order. (7) No engine or fan required. (8) No waste of fuel through the bars. (9) Fireman can regulate and stop the draught instantly by turning a small cock governing the air supply. (10) No extra space required, as the furnace is self-contained. The Meldrum forced draught furnace is beyond the question of a doubt the most popular presented (on the market to-day) of its kind. The sales and the success achieved warrant us in making this statement.



LONGITUDINAL SECTION THROUGH FURNACE.

FIG. 12.

We do not desire to imply it is perfect, such an inference would be untrue, because this efficiency, success, or perfection entirely lies with the person in charge of the boiler. Consequently it wholly depends on the fireman whether its working is a success or a failure. This is a most important point, which the patentees will admit, and which ought to receive their attention, and, if possible, put it beyond the power of any fireman to fail with it if he is so disposed.

Until this is done black smoke is bound to be made at intervals, which proves conclusively that improvement is necessary to make the arrangement more perfect, and not dependent upon the whim and caprice of the fireman. This statement is only too true, as proved many times by visiting the various works where this furnace has been in use. One fireman has made much smoke, while another with the same kind of furnace, working under the same condition in every respect, and with the same class of fuel, has made no smoke that one could complain about.

If we might be allowed to make a suggestion, we should say that automatic action is necessary to make this furnace at all times a reliable forced draught and smoke preventer. Some mechanical device, simple in action, impossible to get out of order, timed to work when the fireman began to fire, and to cease working when all the gases are combusted, would be an admirable acquisition to this furnace, preventing black smoke at all times, and not leaving the furnace at the mercy of the man to make a failure when he chooses.

BROOK'S PATENT GAS FURNACE FOR STEAM BOILERS.

The patentee of this furnace, illustrated below, claims it to be specially suitable for burning small coal, with a consequent saving, in many cases of upwards of 40 per cent., and also to be a powerful steam raiser without creating a smoke nuisance.

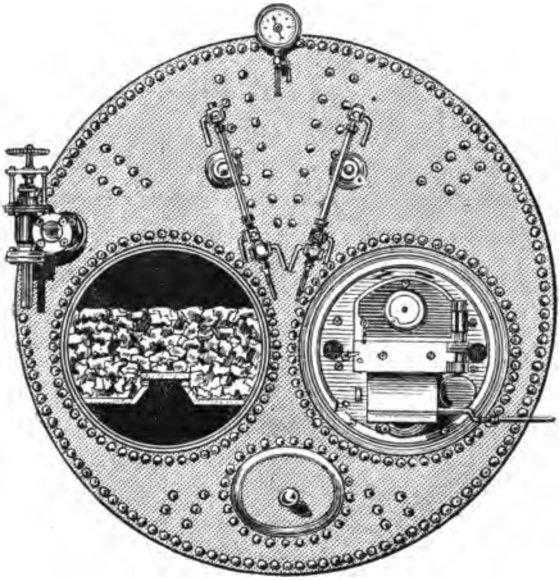


FIG. 13.—BROOK'S PATENT BOILER FURNACE.

This furnace is a new departure, being entirely constructed on new lines. The usual fire-bars are replaced by a combined hearth plate and air channel, which is located in the lower part of the flue, form-ing a blast chamber underneath the same, into which a steam-jet blower forces the air for the fire. By reason of its working with a forced blast this furnace is especially suited for places where bad draught exists, as it will make more steam, and at the same time greatly reduce the smoke—a desideratum which is effected by using a solid hearth plate instead of grate-bars, in conjunction with forced draught. This furnace is particularly well suited for the combustion of small coal, as there is no possibility of waste.

In consequence of the air being admitted to the fire some inches above the hearth plate, and the openings being horizontal, the accumulation of ashes and clinkers does not clog the air openings so soon as with ordinary grate-bars, and consequently it necessitates less frequent cleaning.

The following are additional advantages which are claimed for this furnace:—

(1) A thorough smoke preventer, notwithstanding either bad draught, small coal, or heavy firing. The active combustion, coupled with the special but simple means provided, accounts for its success in this respect, as it will act, under various conditions and strength of draught, with unwavering certainty.

(2) One fireman can drive 800 horse-power.

(3) Thirty shovelfuls of coal may be thrown on at a time, and yet the chimney will remain quite smokeless.

(4) Great simplicity, low cost, no machinery to

repair, less frequent stoking, and less cleaning out. It is a powerful steam raiser, as well as an economical apparatus, and owing to the increased volume of flame in the furnace, the heat is more generally distributed along the boiler, thus greatly avoiding the tendency to strain it, so common with other systems of forced draught.

The peculiar part of this furnace is the solid plate for the fire-bars. At first sight one might be inclined to contend that the principle was wrong, and to imagine that the non-admission of air under the fire by grate-bars would be equal to having dirty fires, and the result would be black smoke. But to make up for the non-admission of air through bars, a powerful blast is applied to the furnace, blowing up the fire, and generating a great amount of heat. In the furnace a bigger body of fire may be kept and worked with advantage if the fireman is so disposed; but, like other furnaces, its efficiency in regard to saving and successful working generally depends, we might say, entirely on the man in charge. The simple suggestions made *re* the "Meldrum" are applicable in many respects to this furnace. When worked carefully, it will produce very good results, while, on the other hand, if negligently fired (like all other arrangements), it will make black smoke.

We will now proceed to discuss the disadvantage or dangers of forced draught. It must be borne in mind that absolute perfection does not exist in the best of mechanisms; there is generally some drawback, slight deficiency, or disadvantage connected therewith, and in justice to all, when speaking on forced draughts in general, we feel it our duty, both to patentee and purchaser, to point out disadvantages as well as advantages. It is only in this way that correct conclusions may be arrived at.

There are many forced draughts now before the public, which are very valuable as smoke preventers, and which we cannot explain in detail; and there are also many that are valueless, and the latter make a great amount of smoke unless excessive care is exercised.

It has been no uncommon thing in our experience to find chimneys emitting from four to forty minutes of black smoke in one hour, made by one Lancashire boiler to which was attached a "forced draught." The leading feature of some forced draughts is to force the gases up the chimney, rather than cause combustion in the furnace. This great liability to make smoke has done the system a lot of harm, and largely divorced public favour.

During the last few years many of the manufacturers have abandoned various systems of forced draught, returning to their old love—natural draught. Being anxious to know the real reasons, we have made very exhaustive inquiries, in order to find out whether sentiment or a saving was the cause. As a result, we were brought face to face with the follow ing facts:—Manufacturers said the forced draught by concentration of heat in particular places burnt the boiler plates, necessitating the boiler being set down and new plates put in; also that the fire-bars burnt away ten times quicker than with natural draught, which it was found, "made it imperative to discontinue the use of forced draught unless the users desired to figure in the Bankruptcy Court." Many of such statements we have found to be true when visiting the various works and seeing the burnt plates and bars. Such facts were beyond dispute.

We have come in contact with many cases where the cost to repair the damage done to boilers and bars by forced draught has been enormous, and one cannot wonder at them throwing the apparatus on the scrap heap; yet one does wonder sometimes at the manufacturers risking the ruination of their boilers by attaching to them forced draughts which have not been proved efficient. In one respect it speaks well for the manufacturers, as it shows that they are prepared to try anything, and go to any cost if they can only prevent black smoke.

Some firms have taken off mechanical stokers, for the reason that they throw out of the chimney small particles of coal. Our attention was called to a particular chimney (a very tall one), which served four Lancashire boilers to which were attached mechanical stokers. The chimney was near a river, and when the wind was in that direction particles of coal were carried across the river, covering the ground for a distance of 300 yards or more. It was an intolerable nuisance, and the only way of abating it was to take off the stokers, and this the firm decided to do. There are some forced draughts which do the very same thing, yet on even a larger scale. For a long time property owners and occupiers in the vicinity of large works have complained of black showers visiting them so frequently, and they were at a loss to understand from whence the nuisance came. They noticed when the works stopped the black rain drops ceased, which caused them to come to the conclusion that they came from certain chimneys. Pressure was put upon the owners of the said chimney, who made investigations, and found forced draught to be the cause, and because of this a good number have dispensed with it.

Those particles which are too heavy to be carried up the chimney, and too light to remain in the furnace to be burnt, find a resting-place in the flues, and places in which they never ought to be found. In the first place, it is a waste of coal; and in the second, it fills the flues much faster than natural draught. This is an item which works out to be very costly, both in coal, the setting down of the boilers, and the extra cleaning of the flues, which does not speak very favourably of the system. If the flues are not cleaned out very frequently, it means less draught and insufficient (even with the artificial draught) to generate the necessary steam. So constant flue cleaning with some forced draughts is absolutely essential.

Some take objection to forced draught because of the great noise it makes. They say: "The noise is an intolerable nuisance, and the remedy is worse than the disease." There can be no question that the noise made in some instances is very much against forced draught, especially when the boilers are near to the shops where a large number of men work, and where talking is necessary to carry on their work. To some men noise is not the slightest objection, while to others (who are very sensitive) it is very objectionable, especially when they are not in the very best of health and temper.

The initial or first cost of adopting forced draught, say, for one Lancashire boiler, is an important item to many small tradesmen. From £60 to £80 is to them a large amount, and makes them often hesitate on that account. We know patentees, like other persons, want large profits, but sometimes their profits are not so large as they would be if they were to charge a little less and sell double the quantity. Then there is the working cost, viz., steam blowing, constantly, or at intervals—a very small item—and the burning away of the piping and various parts of the apparatus inside the furnaces. In some forced draughts the renewal of these parts are rather costly, and we have known some of them to be burnt away in three months.

Again, when common or dirty coal is used, it means larger quantities to get up the required steam, and that of necessity entails more carting to and from the works of coal and ashes. Then there is extra flue cleaning, which we have mentioned, and this is a very big item.

Extra labour is also necessary to assist in cleaning the fires, carrying away the ashes, and in firing the boilers, for the firemen say, that with such fuel, and forcing the boilers, they cannot attend to the usual three boilers, two being sufficient.

If this concession is not made to the fireman, he may get negligent with the extra work, and often by it brings to his master court costs also. The disadvantages in forced draughts we have enumerated show that there is plenty of room for improvement.

THE IMPROVED AUTOMATIC REGISTER SMOKE PREVENTER AND FUEL ECONOMISER.

The Automatic Register (Fig. 14) is a mechanical contrivance easily adjusted for automatically regulating the admission of supplementary and intermittent quantities of atmospheric air to the boiler and other furnaces, both in front and rear of the fire-grates, for the purpose of supplying the necessary oxygen to the incombustible gases during the time they are being rapidly evolved from the fuel in the fire-grates, thereby converting them into combustible compounds, and subsequent smokeless flame. It is so arranged that it controls the admission of air in front of the fire-grate by means of a plate made to slide in a frame fixed

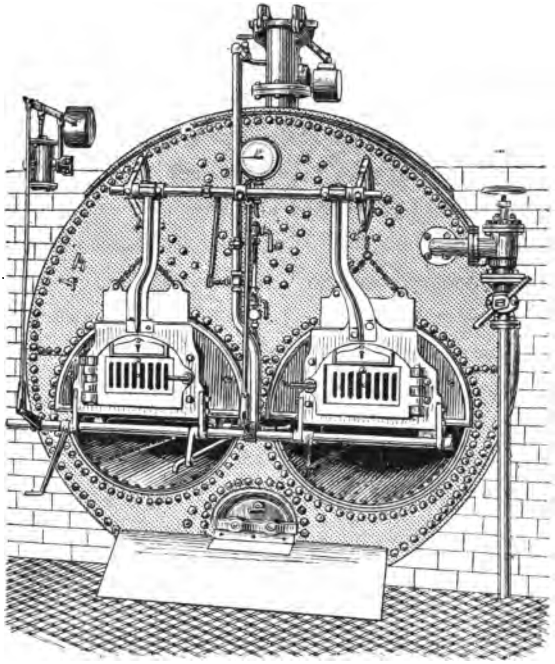


FIG. 14.—THE AUTOMATIC REGISTER SMOKE PREVENTER AND FUEL ECONOMISER.

between the fire-hole door and the furnace front. It also controls the admission of air from the back of ashpit to behind the bridge, either direct or through a heating chamber, by the opening and closing of a flap valve. Consequently the necessary supplementary air can be given to the gases when required, and automatically shut off when not required, thereby causing a gain in the former case and preventing a loss in the latter, which is very considerable with some kinds of fuel. It also controls the opening and closing of steam jets, which are used for the purpose of forcing atmospheric air through or between the grate-bars during the time the air valves are open, the opening and closing of the steam-jet valves being simultaneous with the opening and closing of the air valves, a great advantage when the draught is bad.

It will be noticed that the front air valves are quite independent of the fire-hole doors, and that the fireman, though he may open the doors, cannot interfere with the fires in the furnace until he has opened the front air valves, as they cover the openings through which the fuel is put into the furnaces; and when he opens the front air valves, he must simultaneously open the rear air valves. Therefore he is compelled to make provision for the inlet of air into the furnaces and heating chambers at the bridge, before he has in any way interfered with the fires and closed the fire-hole doors. The patentee also claims the following advantages for the "Automatic Register":—

That it is a perfect smoke preventer. It economises fuel and gives more boiler duty. It is simple, positive in its action, and not liable to get out of order. It can be easily adjusted to suit the requirements of the coal in use. The most inferior coal, slack, or breeze can be used with this apparatus. Any kind of grate-bar is adapted to it. It can be easily applied to any angle or double-flued or horizontal or vertical boiler. It can also be applied to puddling, re-heating, and other such-like furnaces. It is invaluable to boiler-men who have to attend to other work, giving them more time to do so. It is not expensive, considering its efficiency, and it does not require an engine to work it. This arrangement is a revival of the old idea of admitting air into the furnace in the simplest form possible, and doing it automatically. After having tried various systems and arrangements, experts have found, as we have already said, that air is necessary, and the simplest way to admit it, though the method may be old, is the best. This register, when put upon the market, was highly eulogised by many who were considered authorities on smoke-preventing.

It had a very good start, receiving plenty of public favour, and sold rather rapidly. On some boilers, after a time, it was found that the register decreased rather than increased the draught, and the cause of this was the letting in of air at the door to the bridge. When the bridge was closed, and air went through the door only, the draught was better, but when the two were working it was bad. This, no doubt, had not a little to do with the disrepute into which it fell; but there was another thing which, in our opinion, was the cause of its decline, rapid as it was, viz., the lifting of the levers by the firemen at every firing. True, no engine was required to work the apparatus, but a great amount of strength was necessary to lift the levers. The firemen having to do this set their minds against this machine, with the result already named. Had there been no levers to lift we feel certain this register would have had a long and successful run. There are at the present time a goodly number working very successfully in places where the firemen are compelled to pay proper attention to them.

It is known by many manufacturers that a very large percentage of the heating power of coal is wasted through imperfect combustion. It is the office of the simple invention illustrated on page 103 to obviate the loss,and at the same time remove the nuisance of smoke. The sketch conveys a graphic idea of the manner in which the smoke is attacked at the furnace door. The door is so constructed that it produces both a baffle and an eddy or whirl, and heats the air passing through, partially delaying the progress of the smoke towards the flue, until it is thoroughly admixed with the air demanded for complete combustion. It is whilst it is in this condition that when passing over a body of incandescent fuel the combustion is completed. The air is admitted and induced by natural force of draught into the furnace at the door in whirling

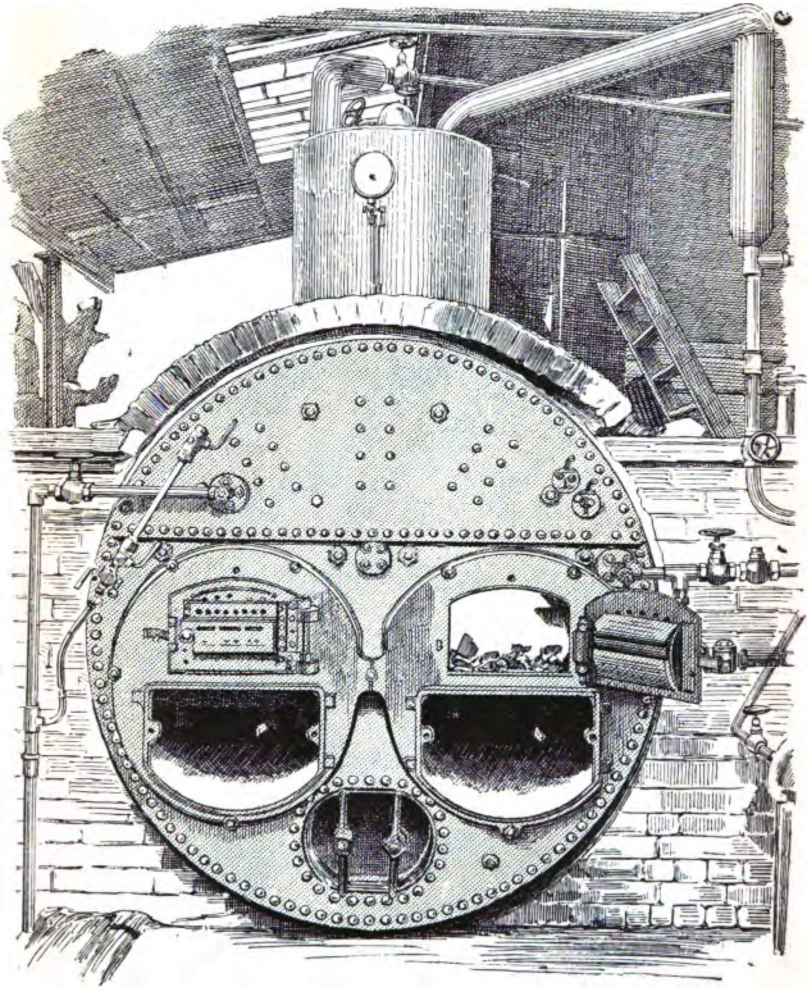


FIG. 15.—THE SMOKELESS INCANDESCENT FURNACE—FRONT ELEVATION.

sprays, heated by radiation, drawing all the generated smoke gases into the vortex thus produced, and ignites, thus increasing the total heat and consuming all the elements which constitute smoke.

In Fig. 16 we have an illustration of what takes place in the furnace by the admission of air through the door. The makers claim the undermentioned benefits from this door:—Superior efficiency over every existing method, however expensive in securing the abatement and abolition of all coal smoke and other noxious and poisonous products through imperfect combustion. To stop the serious waste of coal through imperfect combustion. Great saving in fuel. Smaller and cheaper coal can be used. Change effected without cost in one minute. No machinery, as the action of the invention produces its own beneficial results by natural attraction. No special instruction to firemen.

There is no doubt about the simplicity of this door. Neither would we question the value of admitting air at the door—this is universally admitted to be the proper place; but as to the merits of the baffle eddy, or whirl, we will offer no opinion. Much could be said in favour of a door of this description, yet there is one thing, in our opinion, which is greatly against it, viz., the continuous admission of air, 70 per cent., or more than required for the combustion of the gases, and this, we feel sure, unless remedied, will prove detrimental to it. The principle is good—the place of admission is the proper place; yet to make the door more perfect it needs an automatic arrangement to regulate as required the admission of air.

If we might be allowed to make a suggestion we should say: If louvres, panels, grids, circulars, or something else were worked by a reliable automatic arrangement, opening and closing the apertures in the door for the admission of air, it would meet the requirements. In the first place, it would prevent unnecessary air going into the furnace, and thus causing a waste. Secondly, it would require no attention on the part of the fireman, opening when he opened the furnace door, and closing in a given time automatically, to suit the class of coal; and, thirdly, it would mean a considerable saving, by increased heat in the furnace with the same amount of coal. Such an automatic door would be an invaluable invention for the practical prevention of smoke.

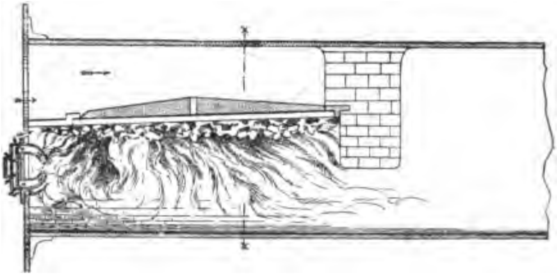


FIG. 16.—LONGITUDINAL SECTION OF THE SMOKELESS INCANDESCENT FURNACE.

There would, however, be one other point to consider in connection with it, viz., the natural draught. If the draught were defective it could be increased to the required amount by putting into the furnace at very slight cost one or two steam jets, which could either work continuously, if short of boiler room, or be worked for a few minutes after firing, and then shut off automatically. By adding the jets there would be increased draught, greater evaporation, and cheaper coal could be used, and, in short, a considerable saving at a very little extra cost. There are many advantages from such a door, even when worked in conjunction with the jets or forced draught. Supposing the jets were working continuously, air would not (like many forced draughts) be constantly going into the furnace, as the regulating door would prevent it, the furnace getting the advantage of the blast and not the disadvantage of air when not necessary. The blast could also be shut off at the same time as the air if essential, and another great advantage from the suggested door would be its economic working either with natural or forced draught.

In our examination of the various patented smoke preventers we commenced by air admission through the grid door worked by hand, we have also carefully considered appliances, both costly and complex, which have been the work of great genius, and years of labour. We now come down to the present day developments, and what do we find? That we have practically come back to the position started from many years ago, viz., the grid door, but with one important addition, and that is automatic action. For the latest development of a smoke preventer is an automatic grid door, proving very conclusively that air admission through the door, though an antiquated idea, was an excellent one, and producing excellent results. If it were wise to do so we could give the names of many firms who have tried thoroughly (at great expense) the best patents on the market, but have dispensed with them, and to-day the firemen are working the doors, with very good results.

On leaving this part of our subject we would say to purchasers, select the simplest, the most reliable, and the one most suitable for your requirements. Test it thoroughly, and if the results are all right, then you need not have any fear for the future, or trouble with black smoke.

CHAPTER VII.

BLACK SMOKE FROM METALLURGICAL FURNACES.

WE have, up to the present, been dealing with black smoke from boiler furnaces only, and have demonstrated that under certain conditions it is not an easy matter to prevent black smoke at all times. But it is comparatively easy to prevent smoke from boiler furnaces compared with metallurgical — commonly called heating—furnaces. Dealing with smoke from heating furnaces is a big question, and bristles with difficulties at every step. Experts on combustion, patentees, writers and speakers on this question, have very studiously avoided dealing with this part of the subject in detail. Some have considered the question in a sort of abstract way, but in the main we may say with truthfulness the furnace question has been untouched. A few Local Authorities do take action against owners of furnaces for making excessive and unnecessary emissions of smoke; this action being taken either under the Public Health Act of 1875, or some Local Improvement Act. The majority of Sanitary Authorities have taken no action whatever on this part of the question. They have somewhat realised the difficulties which have to be dealt with, and such difficulties have deterred them from moving in the matter.

The question we have to consider in dealing with furnaces is, "Can the difficulties be overcome?" To such a question we would reply, "To a very large extent they can." Some persons raise their hands in horror at the very suggestion of dealing with furnaces, and say if attempts are made it means driving away, or even destroying, our trade. To such fearful and sentimental souls we would at once reply that there is not the slightest cause to fear anything of the kind taking place. Let us face the facts, consider the construction of the furnaces, the system of working them, and the kind of work performed by them. If this is done, and we apply experience of the laws of combustion to the furnaces, we shall find that a great deal can be done to practically prevent black smoke, without in the slightest degree interfering with the trade carried on.

We are quite sure that at the very suggestion of any action being taken in regard to furnaces, a great many will be up in arms against it. To such we would say that there is not the slightest intention of doing anything beyond what the Act requires, viz., "To consume smoke in all furnaces and fireplaces, as far as is practicable, without interfering with the said trade or process." To act on such lines, we feel sure, no reasonable man could take any objection. In addition to boiler furnaces, we have paid for a great number of years much attention to the furnace question, considering the various kinds of furnaces, the ways of working them and the results. After careful consideration we have been compelled to come to the conclusion that the opportune time has now arrived to take action; much black smoke can thus be prevented, and this can be done by the adoption of a simple, sensible system of firing the furnaces. Having arrived at this decision, we propose to deal with the difficulties in their several details.

There are all sorts, shapes, and sizes of heating furnaces, to suit the particular class of work they have to do. These furnaces are known by the kind of work they do. For instance, the plate furnaces, which are used for heating armour or boiler plates; the gun, ingot billet, ball, tire, rod, spring, air, and various other kinds unnecessary to mention. There are a vast number of others, yet those named, we might safely say, will, for practical purposes, cover the whole field of furnaces which we desire to deal with. Though there are so many, each in many ways distinctly different from the others, yet with regard to the generation of heat they are one in principle, and because of this we may lay down certain rules or laws for the firing of them, which will be applicable to the whole category of heating furnaces.

Any of the furnaces named, without drawing the slightest distinction, will at various periods make from four to forty minutes of dense black smoke in one hour.

This is not an imaginary estimate, but an actual fact—a thing that can be seen every day in our principal industrial towns and cities. If we turn our eyes in any direction, we see volumes of smoke being vomited out of chimneys coming from various sorts of furnaces. It is no difficult thing to imagine the atmospheric condition. In particular parts it is no unusual thing to walk through dense smoke (when the atmosphere is heavy), groping or feeling one's way, as seeing is out of the question. The question which we desire to consider is whether everything is being done that can practically be done to prevent the immense black smoke from these furnaces? The answer is emphatically, "No."

Our long and varied experience with the different kinds of metallurgical furnaces has proved unmistakeably that the same principles are applicable to all of them in reference to their working. So in our attempt to lay down a few principles, rules, and laws, and to throw out a few simple suggestions, we wish it to be perfectly understood that they are all applicable to each and every kind of furnace named.

In heating furnaces it is an invariable custom to fire them heavily, which means, in simple language, to put on a large quantity—in many instances four times more than common sense would dictate—and this alone is in nearly every case the cause of dense smoke. Putting on too large a quantity reduces the temperature of the furnace, thus making the ignition of the gases impossible, turning the furnace into a gas producer, and emitting the gases into the atmosphere instead of their being combusted in the furnace and generating heat which the furnace requires. The fires become almost dead, which necessitates the fireman breaking them up, or knocking them about, as it is termed, and the result may be easily imagined even by one who is not of a mechanical turn of mind. Here we have the secret of smoke-making in furnaces. Why are they fired so heavily? Ask the furnace fireman this question, and he will, without the slightest hesitancy, say: "Because we want to make it last." This is the truth, and nothing but the truth. Let us look at the answer, "To make it last." The men are practically compelled to fire heavily to make it last, to give them time to do other work between the firings, which work is considered of greater importance than firing the furnace; in fact, the firing is considered an extra, and it is done as carelessly and as hurriedly as possible; and we can truthfully go further and say, under the present system of working it is absolutely necessary for them to fire heavily, or they could not do their other work. This kind of thing is going on during the whole of the working hours, we might say, everywhere, as the same system of working prevails. Things are even worse (if possible) as regards the density and duration of smoke during the meal times.

Having got his heats out, the fireman re-charges the furnace. Then he fires up, putting on sufficient fuel to last fifty, and in some instances sixty minutes, while he goes to dinner. The temperature of the furnace being reduced by re-charging with cold material makes complete combustion with heavy firing impossible, and firing under these conditions even heavier than usual. It is no exaggeration to say that a furnace thus fired will vomit volumes of dense black smoke for twenty or more minutes without any cessation. This sort of thing ought not to be tolerated in a civilised country, especially in districts where dwelling-houses are in close proximity to the furnaces. If a complaint is made, we are at once met with the retort that the man must have time for his meals, which, in other words, means that there is a justification for the smoke. Such a plea is not deserving of one moment's consideration, as boiler firemen are not allowed to leave their boilers for meals or anything else for any lengthened period. What is practicable and applicable to boilers is also applicable to the firing of furnaces. By a very simple arrangement, this heavy, wasteful, and intolerable system of firing (to last the dinner hour) could be dispensed with, namely, by letting one man stay with the furnaces and fire them, as a little common sense would dictate. Such a change of system would be found to benefit both master and men.

There is a decided difference in heavy firing and hard firing. Many firemen cannot, or will not, see that difference. There are some men who make or join the two into one. Supposing a man is short of heating space for the work he has to do, then it is necessary for him to force the fires. By firing heavily he is compelled to constantly knock the fires about, which makes the work heavier still, and the results are less satisfactory.

The difference or the non-relationship between hard firing and heavy firing every fireman ought to be able to discriminate if only for his own sake, to make less work. Heavy firing means rest for the man, expense for the master, and a smoke nuisance for the public Hard firing means hard work for the man, best possible results for the master, and very little or no smoke nuisance.

This to many may seem strange at first sight, for it is invariably said by firemen when complaints of smoke are made that they have to fire hard, which they think ought to be a sufficient excuse for the smoke. When the matter is looked into, it is found very conclusively that those who fire hardest, and on the best system, generate the most heat, burn less fuel, and make the least smoke. It is the man who has to fire hard and who fires heavily also, that makes less heat, gets more fuel through the furnace, and makes a big nuisance into the bargain. This difference is recognised by many firemen, who have beyond any doubt to fire very hard, and they know full well if they were to fire heavily it would be impossible for them to get the desired results from the furnaces. This is proof positive that hard firing, if properly done, will not make dense black smoke. It is the heavy, idiotic, impracticable firing that causes the nuisance.

We have said that heavy firing is wrong in principle under any conditions, whether the furnaces are forced or not, and we wish to emphasise the truthfulness of such a statement. If it is wrong to fire heavily, it must be right to fire lightly. Having said a little about the cause, let us very shortly point out the cure. Light firing, as applied to steam boilers, and what we have said in respect to these, is equally applicable to all kinds of heating furnaces. In furnace firing, as in boiler firing, if it is done lightly and often, there is to be found in it the secret and solution of complete combustion.

The stoking holes, through which the furnaces are fired, are nearly always alike, or very similar to each other. Each one consists of a square hole in the frame of the furnace at the back, varying in size to the requirements of the furnace. There is also a neck of brickwork from 12in. to 18in. to prevent the heat from the furnace heating the frame of the furnace. We would specially call the reader's attention to this fact, to show that a grid, or panel door, could be attached to the heating furnace, for the purpose of admitting the required air, without the slightest fear of the heat from the furnace burning the said door in.

an unreasonable time. This is a point upon which we wish to lay very great stress, for, in our opinion, a suitable door could be fitted to the furnace, a door which would be very durable and suitable for all practical purposes.

Some furnaces have doors with no provision for the admission of air. These doors often fit tightly, and after firing, often heavily, they are instantly closed, with what result we need not state. In the majority of furnaces no doors are provided for the stoking hole, though many of them had doors once, for a short time after the furnaces were put down. But they received such cruel treatment at the hands of the firemen that survival was made impossible; hence the bulk of them are doorless.

The firemen, however, are determined to have a door of some kind or other, so, after firing, most of them make a door of small coal, and some push a thin plate in front of the stoking hole to keep out, as they say, "the cold air."

Either of these provided doors is most unsatisfactory. Both most effectively shut out of the furnace the necessary air, which must be admitted to the furnace if black smoke is to be prevented. If the firemen were to put lumps of coal in the stoking hole, to act as a door, there would be holes or small apertures through which a little air could get into the furnace, and unconsciously and unintentionally, by that kind of door, some of the black smoke would be prevented.

But for some reason or other they have the greatest antipathy to hard coal for door-making, and cast it aside as though it was a corrupt constituent. Smudge or slack, on the other hand, they love, and will use nothing else for making up their stoking hole. The one thing that makes it acceptable to the firemen is that it is easily handled, or shovelled, much more so than the lumps, and this, no doubt, is the principal reason for their preferring it. The smoke never troubles them; it is a question of ease, and ease only. The firemen are great adepts at making these slack doors. So tightly are they jammed that nothing short of a 40 lb. pressure could force air through into the furnace.

Having described the kind of doors used on metallurgical furnaces, and having demonstrated that they are the wrong kind so far as the prevention of black smoke is concerned, let us consider what is required. First of all the door must be a metal one, something similar to the boiler furnace door, fitted with either grids, louvres, or panels, with sufficient aperture to admit the necessary amount of air after firing to consume the gases. These grids or panels must be opened and shut as required by the fireman. If the firemen will not do it—and our experience goes to prove that many of them will not, except when they are watched—then it will be incumbent upon employers to purchase doors which are automatic, and that will open the grids or panels when the fireman opens his door, so that after firing he may close his door, leave it, and the panels will close gradually in one or more minutes, as the firing requires.

CHAPTER VIII.

SPECIAL FURNACES.

THERE are three kinds of furnaces which will require special consideration, because they are distinctly different in the class of work they do to the other metallurgical furnaces which we have already dealt with. They are known as (1) sheet mill furnaces; (2) hardening furnaces; and (3) annealing furnaces. It is said, by men who have worked this class of furnace for many years, that prevention of smoke in regard to them is absolutely impossible. They have never tried to prevent it, and have become so accustomed to making it that they verily believe black smoke is a necessity, and to try to convince them to the contrary would be a thankless task. Many of the men in charge of these furnaces would not allow anyone to make an experiment if they could prevent it, so biassed are they against any innovation. We must candidly confess that there are many difficulties confronting any attempts at minimising the smoke from these furnaces—difficulties with the men who work them, and also with the peculiar nature of the work. Yet, in spite of these, the experiments made have proved that much of the resultant smoke can, with care, be prevented without injury to the trade, and without restriction of output. In dealing with these furnaces for the prevention of smoke, two things must be kept in view, as it is always said by those who work the furnaces that if they were to try to reduce smoke it would spoil the steel, and make it impossible to get the same amount of work out of the furnace. A great deal of this is purely sentiment and nothing else, as we shall be able to show by dealing with these furnaces separately and in detail.

Sheet Rolling Mill Furnaces.—This is a class of furnace which turns out a great deal of black smoke, and those who work them say that the smoke is necessary when finishing off very thin sheets, as it gives to the steel a texture, nature, toughness, making it similar to water marks, which nothing else will; hence to stop the smoke would mean to spoil the steel. We have continually watched the working of these furnaces, and must admit there is a great amount of truth in what is said. The furnaces have to work a very fine class of steel, namely, pen, watch, and other kinds, which require great care in the furnace.

These finishing-off furnaces, as they are called, must not exceed a given temperature, which the furnace man calls a blood red, and with his experienced eye he is able to work the furnace at that temperature by damper and smoke. There is one difficulty in this class of furnace which cannot be overcome, and that is the low temperature. There is not sufficient heat in the furnace to cause complete combustion. To generate the required heat to burn the gases would make the furnace too hot and unsuitable for the class of work it has to do. Facing the facts as they are, we see very plainly that if the work is to be done the furnace must make smoke. To prevent smoke means preventing trade, and for this the Act of Parliament makes special provision. Where smoke cannot be practically prevented without interfering with the trade, that smoke, in the eyes of the law, is considered a necessity, and although a nuisance, it must be endured. When there are two evils, the lesser must be endured, which in this case is the smoke.

The manufacturers have tried many things with the hope of finding out some practical method of preventing the waste of fuel, which is daily poured forth into the atmosphere in the nature of smoke. Firing with gas, structural alterations and devices for dealing with it after leaving the furnace and before admitting it into the air, have been thoroughly tried, and proved impracticable, hence their abandonment. There is, in our opinion, one thing that might practically be done to minimise the nuisance considerably, and be beneficial to the public at large—namely, the raising of the chimneys. There is a very just cause for complaint in this particular, the chimneys being too low—some not more than 20ft.—and nearly all of the manufacturers are sinners in this direction. They hold that low chimneys are necessary, and produce as much draught as they require, while tall chimneys would make more draught than they wanted. Part of this is true; but they forget, or will not admit, that the draught in tall chimneys can be regulated by the damper to suit the needs of the furnace, whether those needs be little or much. The raising of the chimneys from 20ft. to 60ft., 80ft., or 100ft., would not in the slightest degree interfere with the working of the furnace, and that is the primary consideration. The smoke would then be emitted far above our dwelling-houses, removing the pall which sometimes covers them, and thus would greatly lessen the nuisance. We know the cry of cost will be at once raised, which will go dead against the raising of the chimney.

"Hardening" Furnaces.—This class of furnace is very numerous, especially in the steel trade, being used for the hardening of various kinds of articles, such as files, saws, springs, and all sorts of steel for all sorts of purposes. This class of furnace is one of the biggest of sinners is emitting black smoke. If it is mentioned as a nuisance, the users all with one voice proclaim that smoke prevention is utterly impossible in this furnace. There is, we must admit, some truth in the statement, but it is not wholly and absolutely true. Because of the belief that to attempt to prevent the smoke would spoil all the steel in the furnace, nothing has been attempted in the direction of finding out whether it is possible or practicable to reduce the dense volume of smoke emitted without interfering

with the process in the furnace. Some have wished to experiment, and would no doubt have done so very extensively, had it not been for the great amount of sentiment and opposition against them. We do not desire to imply that it is an easy matter to prevent smoke from this class of furnace. It is the very contrary, as there are difficulties to be faced at every step, and these cannot be aggregated, but must be dealt with singly, because the furnaces vary so much in size, the steel worked in the same, and the system of working. That being the case, we cannot lay down a hard-and-fast rule which will be applicable and work well in every furnace.

Most men in charge, or who have anything to do with the working of hardening furnaces, and even their employés as well, labour under the impression that if any air is admitted into the furnace it will at once damage and even destroy their steel. Where such a belief has come from, or how it has got so firmly fixed on their minds, goodness only knows. But there it is, and they cling to it like dear life. Let us look for a moment or two at some of the furnaces, and see if there is any ground for such a belief. Many of the furnaces being old, and having had rather rough usage, the framework does not fit as tightly and closely as it did, which means the continuous admission of a little air to the furnace when not required, reducing the heat, which means a waste of fuel, and not doing the slightest damage to the steel in the furnace. If it does, the damage is so slight as not to be perceptible to the eye or in the tests. This being the case, why do they strive their utmost to keep out of the furnace, after firing, the little air necessary to reduce the density of the smoke, if not to entirely prevent it? We cannot understand why they do it, except it be their belief that it is injurious. The sooner such beliefs are buried the better for everybody. We unreservedly assert that air does not interfere with hardening when admitted in reasonable quantities. That fact being established beyond question, by hundreds of furnaces, ought to instantly bring about the burial of the belief that air is an enemy to the hardening furnace, and such a belief should never have a resurrection.

Many hardening furnaces are worked at a very low temperature, and to prevent all black smoke is impossible. In this class of furnace no attempt is made to prevent it, as the smoke is required to play upon the steel, the action of which, so we are told, is very beneficial to the steel.

Admitting that black smoke is absolutely necessary in the furnace, we naturally ask why are these volumes of black smoke sent into the atmosphere when the furnace requires them. This is a proof that more smoke is made than is needed in the furnace, and must be wasted, creating a nuisance into the bargain To obviate this the furnace ought to be fired more lightly, to make as near as possible the quantity of smoke required, and this ought, by the working of the damper, to be retained in the furnace until it has done its work on the steel, when it should be emitted, not from a low chimney, as is invariably the case, but from a high shaft, thus reducing the nuisance in the shape of black smoke to a minimum.

There are also a large number of hardening furnaces which are worked at a much higher temperature than those we have just considered. In these furnaces dealing with the smoke is simple and satisfactory if they are worked on similar lines to those suggested *re* low temperature furnaces.

The lines laid down are practical and such as no mechanical mind can reasonably take exception to, because furnaces at the present time are being worked by these rules, and the results are all that one can reasonably desire.

If it were necessary, we could give names and addresses of firms who are working their hardening furnaces on the sensible system set forth, and these would require a lot of persuasion to return to the old method. If we cite one case it will be sufficient to show which is the better system for economy, health, and cleanliness.

My attention was called to a chimney which was emitting dense black smoke. It ceased after six minutes' duration, a short interval between the firings, then another smothering of the neighbourhood took place, and this was its character throughout the day.

I went into the works and found it was a medium-sized hardening furnace, used for saws. The heat required in this furnace was about the average heat for a hardening furnace. The man fired it, putting on rather a heavy fire, and stopping up the firing hole to keep out the air.

This was their usual habit of firing, with the result that the chimney was an abominable nuisance to the neighbourhood. The man in charge of the furnace was elderly, and he had worked that and similar furnaces most of his life. In reply to a question, he admitted that the admission of a little air after firing would not in the slightest degree interfere or injure the articles which were being hardened in the furnace. Such an important statement from such a long-experienced person is most weighty and valuable. On his declaration I gave instructions to the fireman to fire, telling him to put on an average fire and leave his door open for about a minute. This he did, with the result that no black or even objectionable smoke was emitted, which seemed to greatly surprise the fireman, no less than it did the hardener. He continued firing in this way, thus abating a terrible nuisance. I had a long conversation with the hardener, who also held that firing on those lines would not in the slightest degree do any damage to the steel, and instead of hindering them it would help in the working of the furnace. Such experimental evidence ought to be enough to induce all those who have similar furnaces to work them on the same lines, and the same good results would follow. What can be done in one furnace can, under the same conditions, be done in another. We could, if required, give many other similar instances which have come under our notice where the smoke has been greatly reduced by firing with a little reason, but these are not needed. We hope to convince the reader that a reform is necessary in firing these furnaces, if they are to be worked efficiently and without creating a nuisance. Having proved conclusively that much of the smoke from hardening furnaces can be practically prevented, it is our duty, and the duty of all concerned, to see that it is prevented.

Annealing Furnaces.—The hardening and annealing furnaces are very closely related to each other; in fact, they are of the same family, and what has been said of the one applies in almost every particular to the other. The annealing furnaces which we refer to are the big ones which are generally used for annealing various classes of wire. The wire is invariably placed in large metal boxes, which protect it from the flame and excessive heat. Annealing very fine wire is a particular process, and a uniformity of heat must be obtained. This can easily be secured by firing the furnace in the same way as the hardening furnace, without the slighest danger of burning the wire, owing to it being in the boxes named. This class of furnace is very numerous, and if any kind needs an improvement in firing this one does. Many of them fire on the old grandfatherly lines, glorying in the clouds of smoke sent out as an evidence, they think, of much work being done. We need not repeat ourselves, but simply say that we have proved often, by firing lightly, and admitting the necessary air through the door, that the dense volumes of smoke may be prevented and the wire annealed to exactly the temper and toughness required, and there is also a slight saving of fuel.

The three classes of furnaces, viz., sheet mill, hardening, and annealing, are the most difficult to deal with *re* the prevention of smoke—more difficult than any other class of furnace, except it be the Harveyising furnace, a big furnace which is used for a patent process in the manufacture of armour plates. This furnace requires the smoke, and all air must be kept out, or the plates are spoilt. This is a very exceptional furnace, and the nuisance from it has to be tolerated if the trade is to be carried on. In spite of all the difficulties, much can be done to minimise the smoke from the three special furnaces named, in a practicable and profitable way. It has been done, can be done, and ought to be done, as speedily as possible.

CHAPTER IX.

MECHANISM TO THE HELP OF MAN.

In dealing with metallurgical furnaces of every kind we have endeavoured to prove, and we trust successfully, that much can and ought to be done to practically prevent black smoke from them by "hand firing," if it be reasonable, and in accordance with common-sense rules. To carry out these rules and suggestions it means one thing, and that is a little extra labour for the fireman, which is absolutely imperative if the good results which can be obtained are to be realised. The same difficulty which has presented itself in the firing of furnaces as they ought to be fired, is found in the firing of boilers, viz., getting the men to do it. They will while watched, but very quickly when left to themselves they get into the old habit of firing, sending out clouds of blackness. It has been found essential to bring mechanism to the help of man in the working of boilers, and it is also necessary to bring into use suitable machinery to help, and even do for the furnace firemen that which they will not do themselves.

Until very recently there was nothing in the market in the shape of machinery or apparatus to deal with anything like effect with the smoke from these furnaces. Patentees looked upon the task as one almost impossible to accomplish, hence they were allowed to do pretty much as they liked. During the last few years the nuisance has become so intolerable

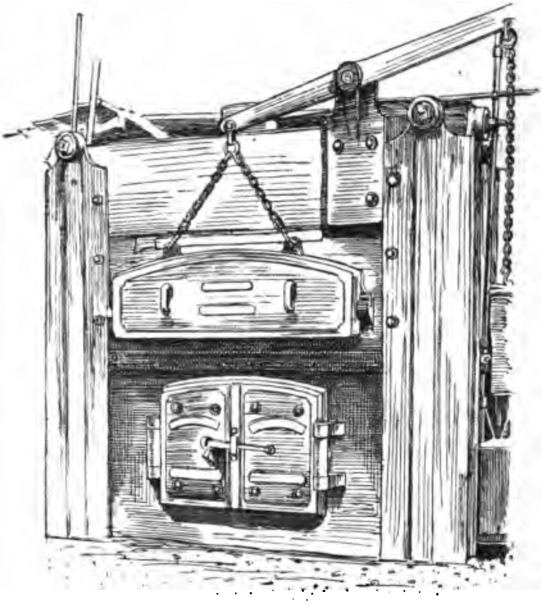


FIG. 17.—MELDRUM FORCED DRAUGHT ATTACHED TO A DOUBLE MUFFLE FURNACE.

that it has moved a few enterprising spirits to commence working to devise, if possible, some mechanical means by which man can be made to prevent the nuisance. We are pleased to state that there are to-day mechanical practical arrangements on the market to deal with the furnaces. The patentees had before them a very arduous duty, but they faced it bravely, have accomplished much, and are in no small way benefactors, who rightly deserve the public praises.

The illustration (Fig. 17) shows the Meldrum's patent forced draught attached to a double muffle furnace. The arrangement is precisely the same as the one they attach to boilers in principle, but in the application often there are slight differences to meet the particular requirements of the said furnaces. I have seen this arrangement attached to the kind of furnace illustrated. It was fired a few times in my presence, according to instructions given, and the smoke emitted was of a very thin brownish colour, not anything approaching blackness. The firings while I was present were very good, and gave me no cause for complaint. I inquired of the men who had charge of the furnace, and they said it seemed to be working satisfactorily. This arrangement had been attached to the furnace a few months when I saw it, which was ample time for them to test it and prove its worth or worthlessness. Men who work this class of furnace generally have an antipathy to any kind of new idea, and sometimes very quickly condemn an apparatus before thoroughly trying it. So we may take it for granted, when the men speak well of a patent arrangement, that there is something valuable in it, unless they have some secret motives for doing so.

Fig. 18 is another illustration of Meldrum's Forced-draught Annealing Furnace.

To have suggested the idea of putting to an annealing furnace forced draught a few years ago

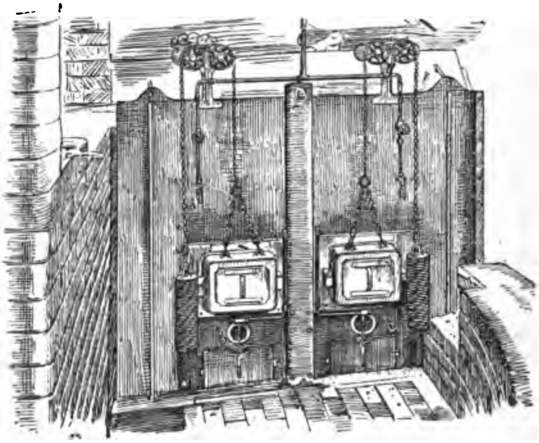


FIG. 18.—MELDRUM'S FORCED DRAUGHT ANNEALING FURNACE.

would have been classed as idiotic. But things have changed. Now we find these furnaces working daily with appliances fitted on them, and to all intents they are doing well.

The incandescent door, which was illustrated and described in dealing with the working of boilers, has also been attached to metallurgical furnaces, with very fair results. This door, which admits air continuously, would be more effective if a little more air was admitted, say, for two minutes after firing, and then shut off when not necessary, as already suggested in regard to boilers. There would then be less smoke, more heat, and a slight saving. There are doors, suitable for all kinds of heating furnaces, which automatically admit the air at the time when it is needed. These doors are simple in construction, accurate and reliable in working, and most effective and economical in the results. They can be attached to the furnaces without alteration. The first cost is reasonable, and is the only cost. When the furnaces require forcing the steam jet can be attached, such an incorporation with the Louvre door making it possible to get much more heat from the furnace, with little or no objectionable smoke.

To lessen any nuisance from the metallurgical furnace, it is imperative that the man in charge of the furnace and the machine should co-operate. The machine, without reasonable and sensible attention from the man, will be of no use; and, on the other hand, in many instances the man is incapable of doing what ought to be done without assistance from the machine. This has been proved hundreds of times with boilers, and it is equally true of furnaces. We think we have said sufficient to show that even metallurgical furnaces can be practically dealt with, without injury to trade, with little cost, and with a considerable amount of efficiency. If dealing with smoke from these furnaces is still ignored when we are face to face with facts proving conclusively that 80 per cent. of it can under ordinary conditions be prevented, practically, then it will be the duty of Public Authorities to compel the owners of these furnaces to do what they ought to do voluntarily.

There can be no reasonable objection taken to a policy of this kind by our Urban and Rural Sanitary Committees, when they, by their Inspectors, prove in the presence of master and man that the furnaces can be worked efficiently with very small emissions of smoke. Furnaces tested in this way will fix the standard of practicability for the various classes of furnaces, or in other words, how much smoke is absolutely necessary under the worst conditions of working. Having found that out, the time could be fixed as reasonable to allow, and if this limit were exceeded, then master and man would be liable for the negligence. By such proceedings justice would be done to the public, to the manufacturer, and to the inventor of the machine designed to bring about those desirable results.

CHAPTER X.

GAS-FIRED FURNACES.

MANY furnaces are fired by gas, and they work well. Under special conditions they are economical, the quantity of work turned out is larger than with coal firing, and what concerns the public most is that there is no smoke. These are facts which no person can truthfully deny, but these results cannot be obtained from every kind of furnace. To fire some furnaces with gas would mean the spoiling of the steel, the losing of the trade, and an enormous cost in addition. We purpose pointing out the kind of furnaces, or under what conditions gas firing is unsuitable and unpracticable, the almost insuperable difficulties to its adoption, and the enormous expense it would incur.

SHEET-MILL FURNACES.

We have already dealt with this class of furnace, making a few suggestions in regard to the working of them with coal fuel, also briefly pointing out the conditions under which they are worked. It is therefore needless to further explain, and we may proceed at once to consider whether gas fuel would be suitable for them. The public complain most bitterly of the volumes of smoke from these furnaces, and not without cause, for they are undoubtedly the greatest sinners in this direction. The complainants say they ought to be compelled to use gas, and abate the nuisance. To such we say that gas cannot be used in these furnaces without destroying the temper and toughness of the steel.

This may appear to some rather a sensational statement to make, and entirely devoid of accuracy, yet we assure them there is every ground or substantiation for the statement.

A very large and old firm of steel manufacturers in a city, which we need not mention, but which we know very well, do a very large home and foreign business in sheet steel. They have many of the sheet mill furnaces, which they noticed pouring out excessive dense black smoke night and day. They were fully conscious of the great waste of fuel, putting out of the question altogether the public nuisance, so they began to seriously consider the question, and after a very lengthened period, having gained all the knowledge on the question they could, they resolved to substitute gas fuel for coal fuel. This firm, we believe we are correct in saying, were about the very first to thoroughly try gas in this class of furnace. They spared neither time, talent, nor money in trying to make it meet their requirements, but they found, much to their disappointment and dismay, that gas fuel was a failure, so far as those furnaces were concerned.

There can be no doubt about their trying every conceivable means to make it a success, because success meant fame and fortune for this firm. But it was all to no purpose. They were compelled to abandon it, and return to the old coal fire. It was impossible to tell how it spoilt the steel, yet it did make it unfit for the purpose for which it was intended, and all their customers said it was not the same class of steel they had been accustomed to receive, and that it was entirely worthless to them. They said, further, that it had not that bluish cast, and did not possess the usual temper and toughness. These customers, it transpired, were not aware that the furnaces were being worked by gas, which proved that their complaints were genuine. The firm was therefore placed between two alternatives, having either to give up the gas firing or lose all their trade. They chose the lesser of the two evils—gave up the gas firing, returning to coal, and were again able to satisfy their customers. Such experiments and experiences are proofs positive that gas firing for this class of furnace is entirely out of the question, and to attempt it would be a wilful waste of money. These experimental arguments are the most powerful, either for or against change, and if people would attach more importance to the experience, and less to what people say they believe, we should get nearer the truth.

Other heating furnaces (except of a special kind) will work well with gas. This is a unanimous opinion. It is also agreed that there would be very little smoke nuisance. Such furnaces, they say, are very desirable, but to procure them is a more difficult task than many imagine. In fact, such a task would be impossible to many small manufacturers, owing to their situation, very limited business, and very limited capital.

To use gas fuel means nothing less than the reconstruction of the furnaces. To rebuild these means the stoppage entirely of business, as it cannot be done without. If there were sufficient convenient space for the building of these furnaces by the side of the others, then work could be going on during the erection of the gas furnaces, and when completed the change could be made without loss of time. This might be done in a few cases, but 95 per cent. of manufacturers would be unable to do it, and for them to make the change an entire stoppage for weeks would be necessary, which might mean to many a permanent stoppage through loss of trade and the enormous expense incurred. It is easy for those who do not pay the piper to say that it can and must be done, but it is quite another thing for those who would have to do it. Before any pressure is put upon them every case ought to be considered on its merits by practical persons from practical points of view, and action taken accordingly, thus preventing injustice to manufacturers and injury to trade. This is not the only cost the reconstruction of the furnaces would entail. There is the putting down of the gas producers. The apparatus itself is very costly. The room required for such a plant is rather large, and the cost of working is no small item.

CHAPTER XI.

GAS FIRED FURNACES.

THE cost of working is a very big item. The furnaces must be worked continuously, day and night, and the week ends also. All this time coal is being burnt, and men's wages have to be paid, while there is no pecuniary profits when the furnaces are not working. If the furnaces do not work the night turn, and are allowed to stand idle during the week ends, then the cost of the producers is very heavy, because gas is being made, going through the furnace, simply to keep up the heat. It is necessary to keep the gas constantly going through the furnaces, whether working or not. Even then, there are men required continually, not only at the producers but at the furnaces themselves, which adds considerably to the cost. There is also an additional cost at various periods, viz., the burning off, as it is called, of the producers, and the cleaning out of the culverts, &c.

To adopt gas firing when there are only a few furnaces which work during the day and not at night would be most costly, and we do not hesitate to say it would be most impracticable. For large heating furnaces which work continuously, where excessive heat is required, gas is very valuable and almost indispensable. With it more heat is not only generated in the furnace, but it can be better regulated than with a coal fire; hence there is more uniformity, which enables the furnace men to gauge much more accurately the heat necessary on the steel. To the manufacturers the all-important advantage is economy. When gas is used on a very large scale it is beyond doubt more economical than coal firing, unless such firing is done carefully and sensibly.

The wide adoption of gas when suitable is a proof of its economy. This alone ought to be sufficient inducement to every firm to use gas when practicable. From a public standpoint the greatest advantage to be gained by gas firing is that there is no smoke nuisance, and this is why there is such a crusade in favour of it. That being the case, we would urge furnace owners to use gas when and where practicable for the sake of the public health, as well as in their own interests. But we must not forget that it is absolutely absurd for any one to contend that gas could be used universally, as in many instances it is found totally impracticable. This being the case, the furnaces must be considered separately, and no hard-and-fast rule can be made to apply to all. More might be worked by gas with advantage, but those which cannot must continue a nuisance, for what gas can do toward abating it? Hence by these facts we are reminded of the necessity to try what can be done before we condemn the present mode of working, and advocate the substitution of something which will be entirely useless in many instances.

Gas should be used where suitable, and where unsuitable some other means should be resorted to in order to abate as far as practicable the nuisance.

CHAPTER XII.

LOW CHIMNEYS.

THERE are in every city and town many low boiler chimneys, far too low for the requirements of the boiler. On the score of expense they are built to the very minimum height. When completed it is too often found that there is an insufficiency of draught, an inability to do the work, and a smoke nuisance in the bargain. Those responsible are frequently called upon by the authorities to raise their chimneys for the sake of public health and public comfort, and the cost is often much more than if it had been taken higher at the first. In big cities there are hundreds of small low chimneys which the authorities have difficulty in finding out, as they are in such out-of-the-way places. These are brought to the knowledge of the authorities by the people in the neighbourhood, who complain most bitterly of the great nuisance they create. We do not desire to imply that the building of low boiler chimneys is the rule; it is the exception, and the exception or custom is far too common, and ought to be restricted with all the rigour which our Councils, under the Public Health Acts, have power to enforce.

Some towns and cities, few in number, do fix a minimum height for boiler chimneys, and below this they must not erect; but above they can go as high as they like, having regard to public safety. Such an enactment ought to be in force in every place where manufacturing is carried on in close proximity to dwelling-houses.

Low chimneys which serve steam boilers are far too numerous, but they are very few when compared with heating furnace chimneys; short chimneys for heating furnaces are not the exception, but the rule. There are a few heating furnaces which are carried into the boiler chimneys, emitting the smoke at 100ft. high, thus abating often an intolerable nuisance. This might be done in numerous instances, with little cost and with great convenience to the manufacturers; but there is one objection to putting the furnaces into the boiler chimney, viz., the boilers are blamed for the smoke from the furnaces, and often have to pay the penalty. This is what the owners say, but the Local Authorities say, looking at both sides of the question, that the furnaces are often blamed for the smoke from the boilers. In many instances furnaces in the boiler chimney assist the boilers to consume the smoke by the excessive heat they discharge into the flues. Many firms who have done this, as they contend simply and solely for the public good, have been prosecuted for excessive smoke, even when emitted at a height of 130ft., which they said came from the furnaces, yet in spite of this they have been heavily fined, the Bench believing that boilers and furnaces were responsible. These decisions have greatly enraged those who went to the expense of putting their furnaces into the tall boiler chimneys, and many of them have gone to an additional expense by taking them out again, and putting them into low chimneys, thus making the nuisance ten times greater. With these very few exceptions, furnace chimneys are all short and far too low. They range from 20ft. to 35ft., which is most unreasonably low—so low, in fact, that if the atmosphere is a little heavy, the smoke cannot possibly get away. It consequently damps down, filling the streets and houses in many instances with smoke, owing to their being so near the chimneys.

The time, we think, has now come when all Municipal Authorities ought to fix, not only for furnaces, but for boilers also, a minimum height, allowing them to go as much higher as they like, but no lower than what is considered reasonable. We should suggest 70ft. at the least, either for boiler or furnace. Such a suggestion, we know, will not be approved by those associated with boilers and furnaces. But, in our opinion, the suggestion is quite rational, and to such a uniformity of height none could object with any good ground, and only those would who would have to pay the penalty. All new stacks, of whatever kind, whether for boilers or furnaces, ought to be built to a height of not less than the one fixed by the Council or Board of Health. Low chimneys have become so numerous, and men have got so used to them, that they believe a high chimney would not answer for furnaces. But the time has arrived when these foolish beliefs should meet the fate they deserve. It is said that the draught from a high chimney would be too strong and unsuitable. Such a contention is foolish in the extreme. It is true the pull on the furnace would be greater, but that could be regulated by the damper to the needs of the furnace. There is no rational objection to higher chimneys except that of cost, and this ought not to be considered, as it is comparatively small when compared with the public comfort and public health.

These remarks in favour of high chimneys warrant us in saying that not only should new chimneys be built higher than is now the custom, but that all the existing low chimneys should be raised to the reasonable height suggested. Many such, owing to age and being badly built, could not with safety be raised. These ought to be pulled down, and stacks suitable, both in size and height, put up in their places. If furnace smoke is to be practically dealt with, higher chimneys are an absolute necessity. This is a big business for any Health Committee to undertake, because there are so many interests involved, such interests being interwoven, and one never knows to what extent. But in spite of this, life and health demand it, and we trust all Corporations, Local Boards, and County Councils will follow the example of the few towns which have had the moral courage to fix the minimum height of boiler and furnace chimneys. Such a law has proved by no means a small factor in reducing the smoke nuisance. Some having taken this step, which has proved satisfactory from all points of view, why not others ?—nay, why not all ? If those whose duty it is to take the initiative will not move in the matter, then the only course open is for the public to put on a little pressure to make them move and do that which is a duty they owe to the public. We do not suggest or imply for one moment that if such a law was in existence that notices should be served simultaneously on all the firms who have low chimneys. The very worst offenders should be taken first, then the others, so that in a comparatively short time, without undue pressure on the owners, the whole of the low chimneys would be raised to the stipulated height. To this procedure none could justifiably take any exception. We trust such a crusade will be at once started and persisted in until all our manufacturing chimney tops can be seen by the Inspector from the public streets, so that when nuisances do exist, through negligence or any other cause, they can at once be seen and steps taken without delay to abate them.

CHAPTER XIII.

GENERAL CONCLUSIONS.

It has been our object in the course of these articles to consider the smoke question from a practical mechanical point of view, pointing out the every-day working and the every-day difficulties. If we have not succeeded, it has not been our fault, or for want of intention and desire to do so, but our misfortune. In like manner we have tried to place before our readers the practical points which are often ignored in the firing of furnaces.

We have not attempted to deal with the many theories extant on this question, but have confined ourselves to the simple rules known to most firemen, feeling sure they would be better understood and appreciated, and productive of greater good, than merely dealing with fancies and fads which are neither practicable nor possible. We have endeavoured to show that much can be done by simply firing the furnaces, if properly done, to reduce the volumes of smoke therefrom. If we have succeeded in proving this—and without the slightest egotism we venture to submit we have—then what remains to be done is to enforce those rules laid down most rigidly to the very limit of practicability. The requirements of the Public Health Act of 1875 are as follows:—"All furnaces and fireplaces must be so constructed and worked to consume as far as practicable the combustibles used therein." This section covers or incorporates all classes of furnaces of whatever kind. It is very necessary to remind masters and men who work these furnaces, or have anything to do with the management of them, of the existence of such a clause.

There is a general impression abroad that all kinds of furnaces are exempted in the Public Health Act. Some go further, and say emphatically that the Municipal Authority have no power over them, or, as they often say, cannot touch them. How this impression has got fastened on their minds we cannot understand, unless it is because the Authorities have never taken action against them, or even insisted on their doing anything to try to prevent smoke. As a matter of fact, the Act does deal with this matter, and the Authorities have power to control furnaces, the same as boilers. This fact will be a revelation to most men, and not a very pleasant revelation either.

The Act in regard to furnaces has been practically a dead letter. It needs bringing to daylight, resurrecting, placing before masters and men, as a reminder that it must be obeyed, or prosecution and punishment will follow. We hope the bringing of this fact to light will stimulate them to the faithful discharge of their duty to others as well as to themselves.

In what way can the provisions of the Act be practically enforced? By co-operation of machinery and men. All the machinery we have mentioned is in the market. It is well designed and constructed, and finished in the finest of style; it has been tested and proved to procure the best results; and it may be obtained at almost any price to suit the pockets of all.

But these appliances are of no use in the market, they need attaching to boilers and furnaces if they are to be of any service in the solution of this question. The prejudice against machinery is exceedingly great and it is often condemned before trial unless certain parties are handsomely or heavily bribed. We know of what we speak, having come in contact with many simple and effective arrangements which have simply been killed because their manufacturers have not had a purse big enough to bribe certain persons in place and power. Such a system is too prevalent amongst all sections of the commercial community, and the effects are most pernicious, being entirely opposed to the progress of any apparatus or patent. This prejudice against machinery, whether caused by the absence of bribes or some other unjust thing, ought to be removed, and a fair test and trial given to anything of merit, whether it belongs to a rich or a poor man, and if found of any value it ought to be adopted. If this policy were pursued it would stimulate the inventor to greater diligence. The Act, common sense, and common justice to all, demand the application of that machinery which will help to lessen the nuisance. The machinery is of little use without the man. The fireman must co-operate with the machine. Without the man the machine would be useless, but the two in combination can accomplish what is desired. We say without the slightest hesitation that if the man and his machine will become familiar friends, if the man will like or even love his particular machine, he will then treat it with care and great consideration, and the result will be the prevention of at least 80 per cent. of black smoke from metallurgical furnaces.

The question is, Are we ready for such a radical reform? We venture to think that such a change, being so sudden and so great, would frighten many people, causing them to wonder if they had been transferred to another clime altogether. This atmospheric change could be produced at once, for there is nothing lacking to accomplish it. There is the money, the machinery, the men, the mind, and the law; but these want putting in motion, and the sooner they are in operation the better. The commencement is the difficulty. Who or what is to do it? Well, if patriotism will not, if the offenders care not one jot or tittle for the welfare of others, then the law must be put in motion to bring about the desired radical reform.

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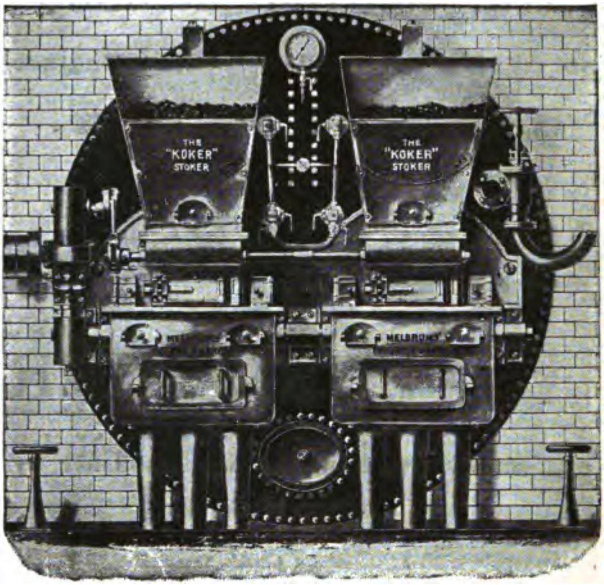

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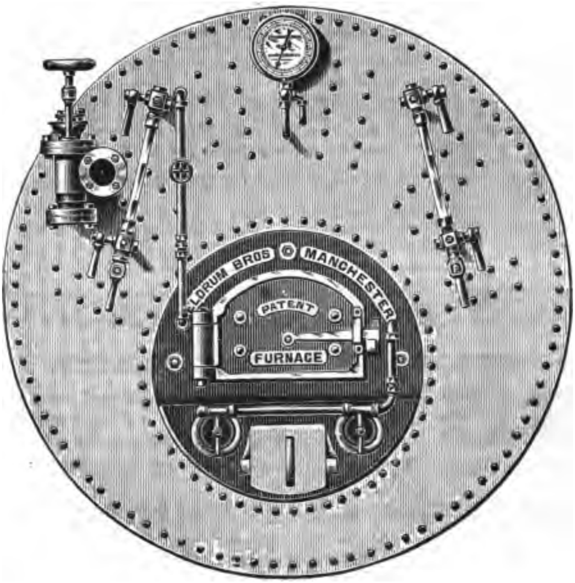

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